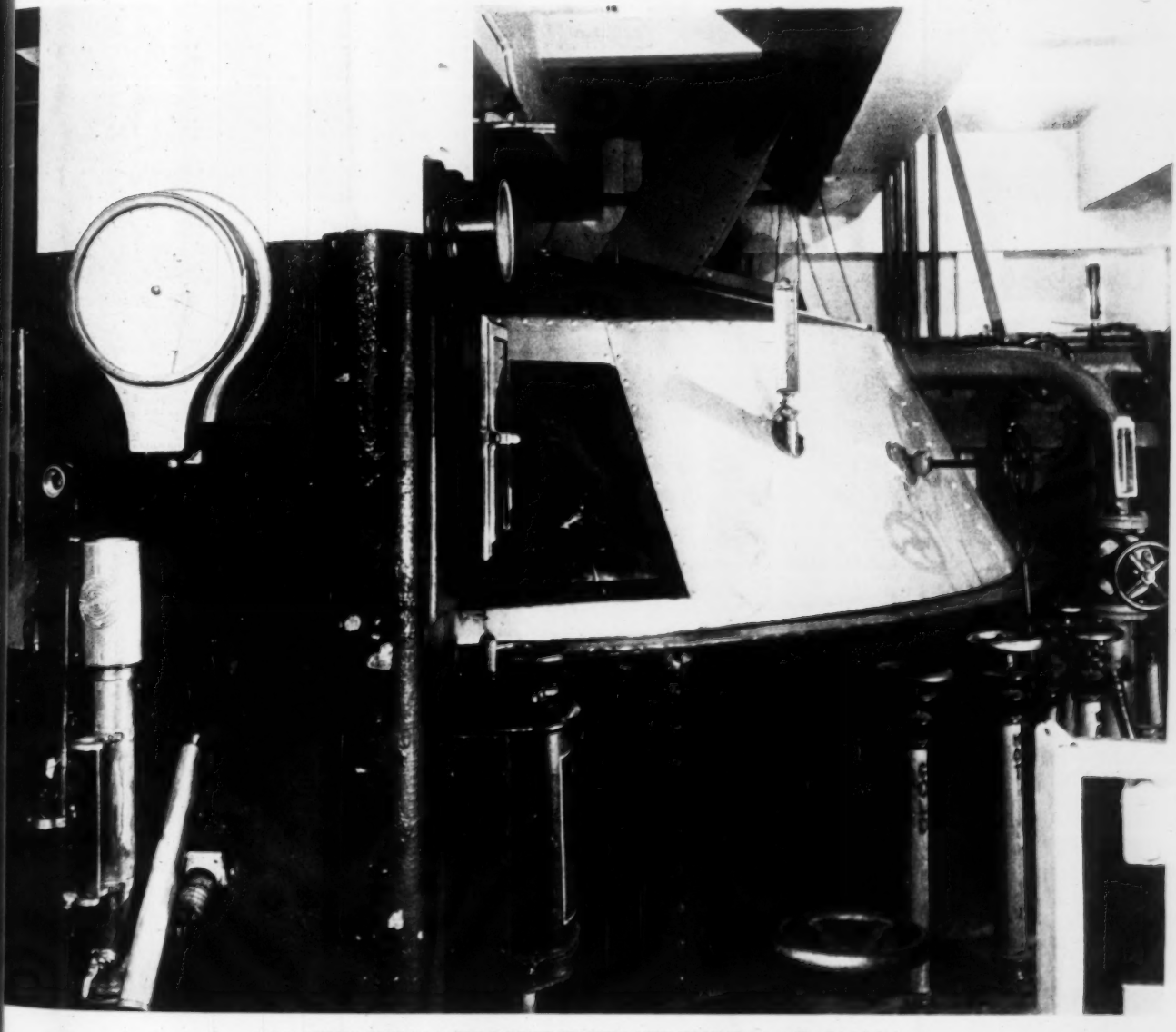
INSTRUMENTS

THE MAGAZINE OF MEASUREMENT AND CONTROL

VOLUME 6 JUNE, 1933 NUMBER 6



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INSTRUMENTS

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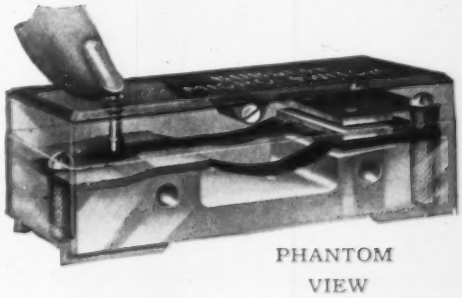
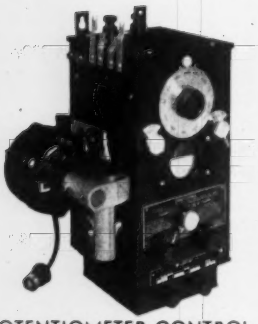


PHANTOM VIEW

"COMPLETE TEMPERATURE CONTROL"
—by Foxboro



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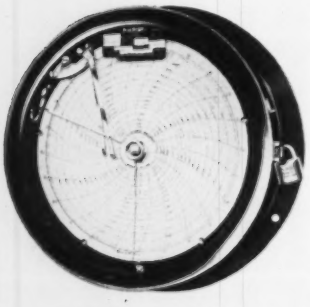

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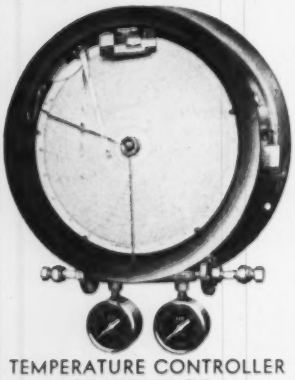

TEMPERATURE CONTROLLER OR "STABILOG"
Write for Bulletin 177

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EDITORIAL COMMENT

In This Issue

♦ Much more than is connoted by the title **Precision Automatic Weighing** is contained in the article by Messrs. **Close** and **Marshall.** They cite instances where weighing is but the method of measuring other variables that have to be determined (and sometimes recorded) in industrial plants and research laboratories.

♦ This month's instalment of **The Engine Indicator** by **Professor De Juhasz** deals with mean pressure indicators. No need to tell our technical readers that M.I.P. is often *the* value to be sought.

♦ In addition to control stations, resistors are dealt with this month by **Spangler** in his series on **Control of Fractional Horsepower Motors.**

♦ And this month's instalment of Flow Measurement and Control discusses means of checking large positive gas meters without taking them to the shop. It's done by means of **portable provers.**

♦ Did you ever notice, in reading the **New Instruments** section month after month, that it consists largely of descriptions of new devices that are *not* instruments? That's because our readers practice the doctrine, "Whatever can be measured can be controlled." Controllers start with measuring elements but end up with motors, valves, etc.—and in between there usually is some sort of a relay. Yes, the field of Instrumentation is very wide indeed!

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The Front Cover

♦ As you may have read in the papers, an amber fluid which disappeared from the United States in 1920 is again on tap here and there. The best brews of the pre-Volstead era owed their uniformity to process control, achieved by instruments. Some of these instruments are back on the job "as good as new" after 13 years' vacation preceded by 13 years' service as in the case of the Bristol recorder illustrated.

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In Coming Issues

♦ Two subjects of current interest: modern brewery processes and the World's Fair. Next month, an article on the former. As to Century of Progress articles, we are snowed under with general publicity write-ups (which you can read in other publications) and we shall print only exclusive and pertinent Instrumentation items.

The New Deal and Business Ethics

DURING our last month in Pittsburgh, before this magazine moved to New York, we visited Western Pennsylvania and Eastern Ohio industrial plants where Instrumentation flourishes, and several large research laboratories where the Instrumentation of tomorrow is being cradled and nurtured.

A chance remark, referring to a long-standing difference of opinion between one instrument firm and one large instrument-using plant, made us endeavor to analyze the causes of friction and to learn whether the nation-wide re-awakening, associated with the "New Deal," was bringing about a greater mutual appreciation.

The bitterest controversies seem to have resulted from little things. No one ever committed any heinous crime. In every case investigated (and we want to compliment both the instrument users and the instrument manufacturers for their admirable candor) a wee little bit of verbal sand had been dropped into a smoothly running relationship, with the natural result that the bearing blamed the journal and the journal blamed the bearing. Who had dropped the sand? Perhaps the gritty grains, with the utter perversity of inanimate things, had insinuated themselves between polished companions. Let it go at that! It doesn't matter now.

What matters is that the Rooseveltian pleas are apparently being heeded by instrument users, by manufacturers, and by manufacturers' sales engineers. Whether stimulated by the White House, whether spontaneous, or whether engendered by a feeling that happy days are here again—there is less "holding out" on the part of buyers, makers and vendors of instruments. There are almost no more conscious misrepresentations, groundless complaints or unjustified money-back demands.

To be sure, the millenium has not arrived. People still go in business for profits. Sales engineers, although they deserve more than ever the thanks of users and makers, still number in their midst a few "promise-anything-to-get-the-order" sinners. Manufacturers still print a few exaggerations. And some users still display cynicism and intolerance toward the most ethical of those who try to serve them.

Of late, however, both the maker and the user have become more appreciative of the other fellow's viewpoint. This is the main thing, after all, because industrial instruments aren't ordinary commodities like beans or chairs. For every industrial process application there are various ways of doing the measurement and control job, and it usually takes more heads than one to determine the One Best Way. It is just as silly for the plant engineer to withhold details and challenge the instrument firm's engineer to solve the problem blind, as it is for the latter to assure the former that *his* device can do the job when he himself doesn't know the details of the job.

Get together! Show your cards! Ask and answer all relevant questions! Don't hold out! Give the other fellow a chance!

Above all, don't nurse grudges. If you think you have a grievance, get it off your chest, talk it over with the other fellow and give him a chance to explain before you accuse him of being the one who dropped sand in the bearing. Better still, never mind who dropped the sand: take it out and apply in its stead some of that wonderful lubricant known as the milk of human kindness.

For example, that difference of opinion—of nearly twenty years!—to which we referred above. Knowing both parties to be honorable and sincere, we rushed in where angels feared to tread, had one long talk with the head man in Ohio, another with the president of the Brooklyn instrument firm and . . . well, henceforth they won't need us: they or their representatives will talk things over in a friendly way—as good friends who understand and respect one another. And that's how it should be everywhere!

We are all colleagues in one esteemed profession: All men who invent, design, build, sell, specify, apply, install, service and maintain measuring instruments, meters and automatic control equipment belong to one fraternity that strives to make better things for mankind and to eliminate human drudgery.—M. F. B.

THE REVIEW OF SCIENTIFIC INSTRUMENTS

With

Physics News and Views

F. K. RICHTMYER, Editor

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With the co-operation of the National Physical Laboratory

Volume X MAY, 1933 Number 5

The English journal devoted to scientific instruments, their principles, construction and use. Essential to all up-to-date designers, makers and users of instruments.

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PRECISION AUTOMATIC WEIGHING

By JOSEPH K. CLOSE* and C. O. MARSHALL†

MANY different types of testing devices are in common use in modern industry. Manufacturers have discovered that the characteristics of materials and products are best determined by such instruments. Actual tests, rather than time-taking observations and meticulous measurements, are now the ultimate criteria by which industry judges its products. It is the quick, accurate, modern way, in step with present-day production methods.

Concurrent with the trend toward testing machines has been the growth of precision automatic weighing devices in this field. It is possible to convert any kind of a force into a pull against gravity. Such instruments balance the pull of gravity on a pendulum against the particular kind of force to be measured. Such a force may be an elastic force, or it may be an electrical force. It may be a force set up by the heat of engines in automobiles, by the action of an air-stream upon an aeroplane, by the out-of-balance condition of a rapidly rotating or reciprocating part such as a connecting rod or aeroplane propeller, by the specific gravity of a liquid or by the density of a solid. The point to remember is that all such forces, in addition to many others in various fields, are forces which can be made to manifest themselves in terms that can be measured by their pull against gravity.

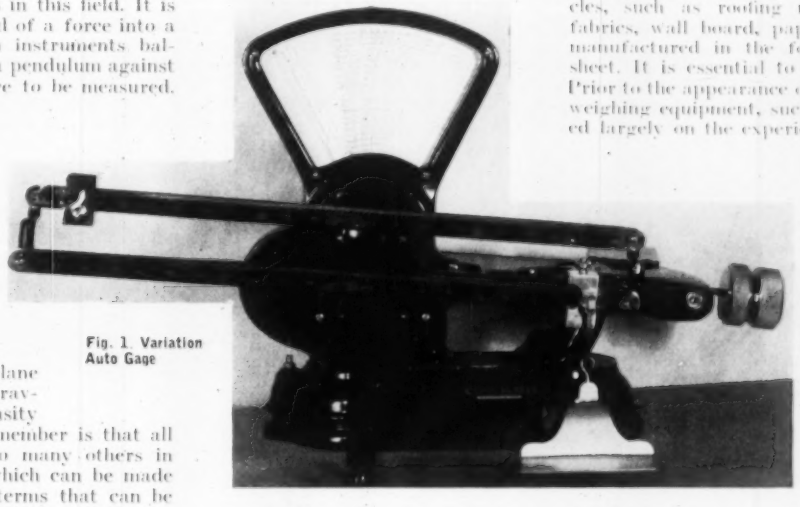


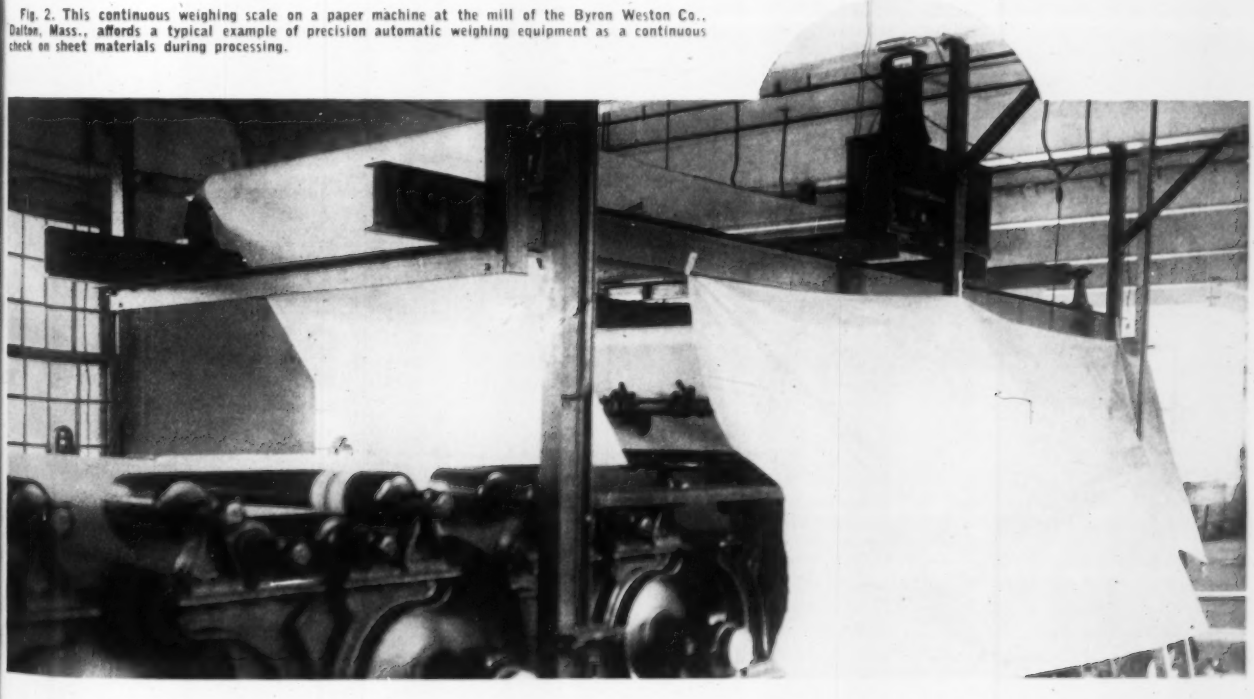
Fig. 1. Variation Auto Gage

Hence precision automatic weighing devices can be used to measure practically any known force. As stated, the application of the pendulum principle to counterbalance a load is the basic feature of such devices, and this feature is operated by the constant attraction of gravity. Since it is not subject to variations in temperature or to the physical characteristics of materials used, this attfaction is an ideal force against which to balance forces to be measured. The inherent advantages of gravity as an ideal testing medium are evident in the increasing adoption of automatic weighing devices for testing products and materials in all branches of industry.

Consider some of the various devices employing the pendulum principle that are now in widespread use. For example, many articles, such as roofing materials, rubberized fabrics, wall board, paper and the like, are manufactured in the form of a continuous sheet. It is essential to maintain uniformity. Prior to the appearance of precision automatic weighing equipment, such uniformity depended largely on the experience of the operators and "rule of thumb" checks. Actual tests amounted merely to cutting samples and measuring with micrometers, or even only weighing a completed roll. As tolerances frequently exceeded 5%, it is apparent that none of these methods insured constant regularity of the product. Naturally the regularity of the material would be reflected by its weight. The adoption of a checking device constructed on the pendulum principle rectified such tolerances. With such an "auto-check" device, testing is at the same time both automatic and accurate. A sheet of material is laid over three rollers. It is a scientific fact that the weight of the material will be distributed over the

*Technical writer, Cleveland, Ohio. †Toledo Precision Devices Co.

Fig. 2. This continuous weighing scale on a paper machine at the mill of the Byron Weston Co., Dalton, Mass., affords a typical example of precision automatic weighing equipment as a continuous check on sheet materials during processing.



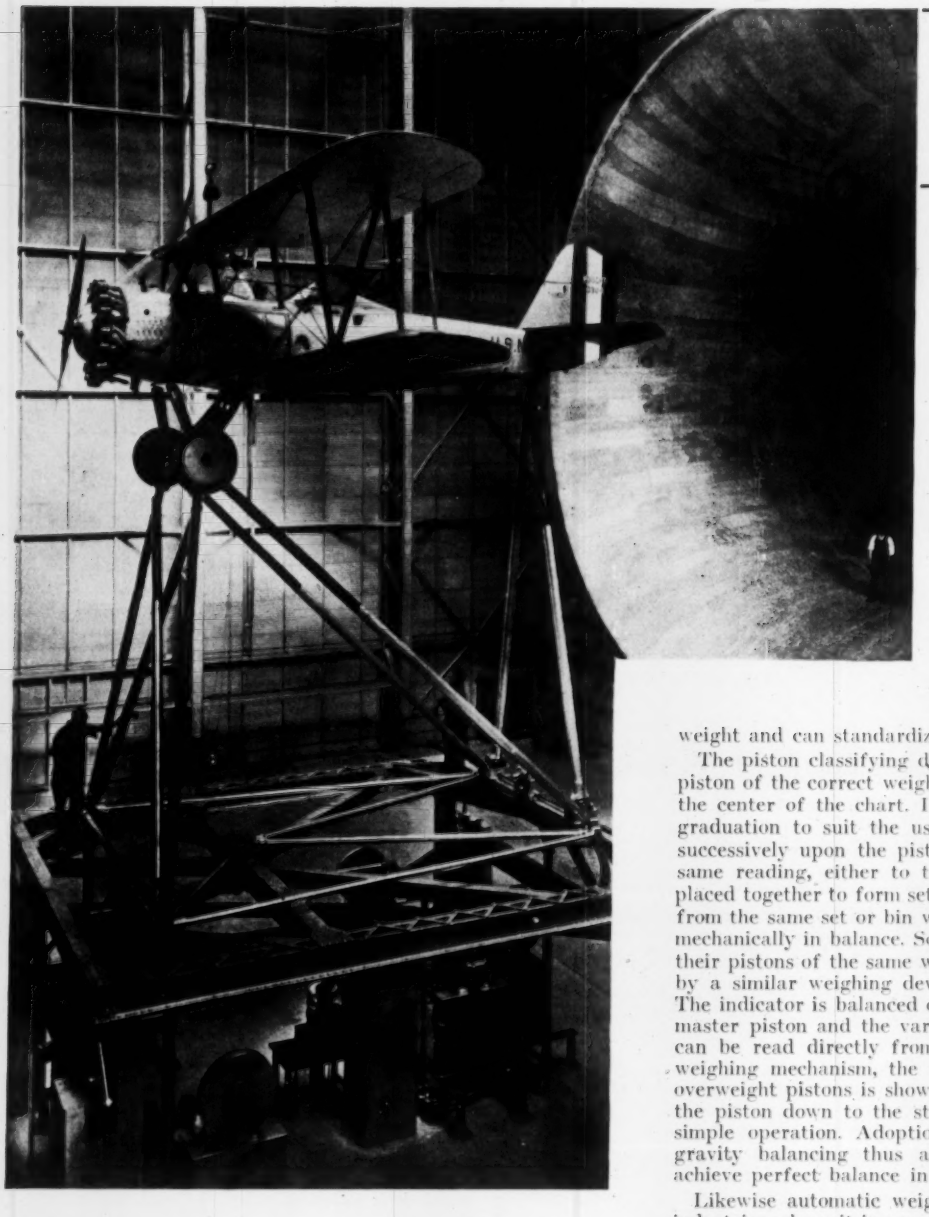


Fig. 3. The wind tunnel and automatic force-measuring equipment for testing full-size aeroplanes at Langley Field, Virginia. Five automatic scales may be seen at the bottom of the framework.

three rollers as follows: ¼ of the total weight will be supported by each of the outside rollers and ½ by the middle roller. The middle roller is mounted on the weighing mechanism and is the weight or load element of the device. The reading of the device is the weight of the middle two yards of material. The load, represented by the desired weight of the material being made, applied to the roller is counterbalanced by an appropriate beam and poise. Then a pendulum—equipped with a pointer traveling over a chart—indicates any variation from the predetermined correct weight. In the use of this scale, it is desired to know only whether the material being manufactured is lighter or heavier than the established weight. This device is equipped with a predetermined weight chart having a zero line and "over" and "under" graduations on either side. The beam is graduated so that the poise may be set to the weight desired for the material being manufactured. Then the indicator will point to zero only when the material of the proper weight is passing over the weight roller. Such a device may be placed right in the production line and gives immediate notice of any variation from the predetermined weight standard. This auto-check weighing mechanism gives instant warnings of variation from standard weight, eliminates waste by avoiding overweight and sampling, and improves the quality of the finished product by obtaining greater uniformity. See Figs. 2 and 4.

The automobile industry also has found testing devices constructed on the gravity principle of great aid in securing more uniform parts. Manufacturers have long tried to eliminate vibration in their cars. Vibration is eliminated by perfecting the mechanical balance of the motor. Such vibration, produced by moving parts—having either reciprocating or rotary motion—which are mechanically out of balance, creates destructive forces within the machine. One of the most important facts relating to it is that the destructive forces set up increase approximately as the square of the speed of the moving parts. Hence it is necessary to keep the reciprocating and rotating parts, such as pistons, of the same weight and center of gravity. Now an automatic weighing device can classify pistons into sets of the same weight and can standardize pistons to one weight.

The piston classifying device is usually balanced to a master piston of the correct weight; so that the indicator is flush with the center of the chart. It may be balanced, however, to any graduation to suit the user. Pistons to be tested are placed successively upon the piston rack and all those that give the same reading, either to the right or left of the center, are placed together to form sets. Hence an engine built with pistons from the same set or bin will have its main reciprocating parts mechanically in balance. Some manufacturers desire to have all their pistons of the same weight. This too may be accomplished by a similar weighing device. The chart is marked in grams. The indicator is balanced on the center position by means of a master piston and the variance in weight of the other pistons can be read directly from the chart. By means of a second weighing mechanism, the weight of the chips machined from overweight pistons is shown, thus allowing the operator to cut the piston down to the standard weight in one complete and simple operation. Adoption of the fundamental principle of gravity balancing thus allows automobile manufacturers to achieve perfect balance in their pistons.

Likewise automatic weighing equipment is invaluable to all industries where it is necessary to determine the moisture content in materials, for instance, lumber. It is a simple truth that moisture content can be expressed in terms of weight. But the more important fact is that such moisture content can be easily, quickly, and accurately obtained by employment of the proper type of weighing device. One up-to-date testing device for this purpose makes use of a fan type scale (Fig. 1) which accommodates test pieces of lumber ranging from 2 to 50 ounces in weight. On the front of the scale are two beams of 500 graduations each. A pan providing the variable leverage necessary in the operation is suspended from the beam on the lower poise to hold the test pieces of lumber. A test piece is placed on the pan, and the scale indicator will move to the right of the scale chart. When it comes to rest, the operator takes the number on the index line, for example, 457. Then the poises on the two beams are set at 457. The sample is replaced on the pan; again the indicator moves to the right side of the chart. The indicating line will then coincide with the zero mark on one of the percentage lines of the scale chart. The letter of this percentage line is noted, in this case, D. The piece of lumber is then dried. To find the moisture content previous to drying, the poises on the upper and lower beams are set at 457. The piece is then placed on the scale platter, and indication on line D is noted. If it reads 14, the moisture was 14% before drying. When it is necessary to reduce the moisture content of an entire batch of lumber from 14% to 5%, frequent tests may be made with the sample piece. When the indicator registers 9%, the amount of moisture removed from the sample. 5% moisture remains in the wood. Kiln operations may be adjusted to this amount. If desired, the device may be placed on top of a drying kiln with a wire extending into it. On this wire

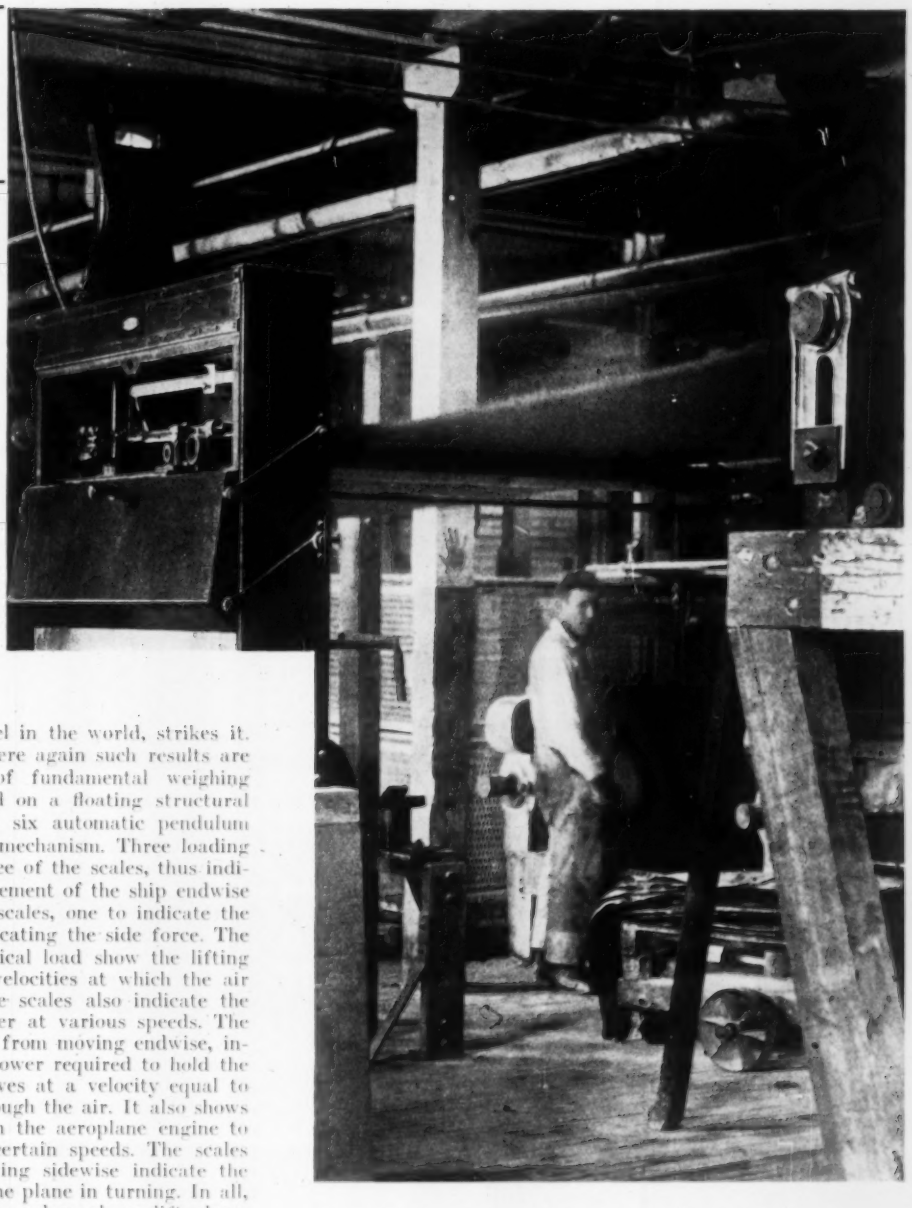


Fig. 4. "Auto-check" weighing device at du Pont Fabrikoid plant, Fairfield, Conn. Gives instant warnings of variations from pre-determined standards in continuous weighing of sheet materials.

a test piece is placed. The upper and lower beams are set at the proper place. In this way, the progress of the drying operation can be accurately noted at all times. Hence adoption of a fundamental weighing principle results in advantages hitherto unobtainable in the lumber industry.

A specific example where proper weighing equipment has produced revolutionary results is the Langley Field Air Tunnel in Virginia. Here scales tell the government what happens to an aeroplane when a hurricane of wind, sixty feet high by thirty feet wide, traveling at 115 miles per hour, shot by fans driven by two 4000 H.P. motors through the largest wind tunnel in the world, strikes it. It is scales that give the figures. Here again such results are obtained by scientific utilization of fundamental weighing principles. An aeroplane is mounted on a floating structural steel frame which is supported by six automatic pendulum type scales equipped with printing mechanism. Three loading struts rest on the mechanism of three of the scales, thus indicating lifts or pressure. Lateral movement of the ship endwise or sidewise is transferred to other scales, one to indicate the end drag of the plane and two indicating the side force. The three scales which support the vertical load show the lifting power of the plane at the various velocities at which the air is forced through the tunnel. These scales also indicate the torque required to turn the propeller at various speeds. The one scale, which holds the platform from moving endwise, indicates the drag or the amount of power required to hold the plane stationary when the wind moves at a velocity equal to the speed the plane would move through the air. It also shows the excess or deficiency of power in the aeroplane engine to overcome the resistance of air at certain speeds. The scales which hold the platform from moving sidewise indicate the force of the air against the side of the plane in turning. In all, thousands of determinations can be made such as lift, drag, pitch, rolling and yawing movement from which the various forces in the aeroplane members can be ascertained to determine the strength in the component parts of the plane. The scales are equipped with a ticket printing device which is highly important in securing accurate results. In any test, at the moment when the operator wants to take the scale reading, he presses a button at a central point, and the actual indication of each scale at that instant is recorded on a printed ticket. As mentioned, the weighing equipment installed at Langley Field allows the government to gain an accurate knowledge of aeroplane performance under all types of flying conditions. Such knowledge is impossible without automatic weighing equipment.

An article of this type might continue indefinitely, pointing out the advantages of weighing equipment and weighing devices to modern industry. Suffice it to say in conclusion that today precision automatic weighing equipment is enjoying ever-increasing acceptance because it gives in many instances accurate findings not otherwise obtainable.

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The Bristol Company's New York office was moved on May 1 to the Daily News Bldg., 220 E. 42nd St. District Manager C. W. Williamson continues in charge, assisted by 6 application and service engineers.

Harry Hudson Cutler, electrical inventor and founder of the Cutler-Hammer Co., died on May 20 at his Miami home.

Electricity Metering And Legislation

To the Editor of *Instruments*:

A few of the measurement standards in this country have their use controlled by laws and ordinances, and among these to some extent are the electrical standards. Congress in 1894 fixed legal values for the ampere, volt and ohm, but there are as yet no acts of Congress which control electricity metering. States and municipalities exercise control over metering electricity, mostly by regulations of public service commissions. These regulations vary in the different States. Watthour meter errors allowed vary in the different States both for light loads and heavy loads. The maximum error allowed in such readings in many States is 4% each way for light loads; for heavy loads, the allowed error is often 1% each way, though some States do not differentiate loads, and allow 4% over the scale range.

With the advent of the Federal tax on electric current arises the question of metering regulations, especially in the light of the fact that modern meter equipment facilitates an accuracy of at most 1% each way at light loads and ½% each way at heavy loads. To some, the Federal tax on current spells the ultimate enactment by Congress of a law specifying errors allowed in watthour metering of current sold in interstate commerce. It will be interesting to watch how the utilities view this possibility, and what effect it has on their attitude towards the continuation of the electricity tax.

Washington, D. C., May 26, 1933 WM. E. BULLOCK

The ENGINE INDICATOR

Its Design and Theory

By KALMAN J. DeJUHASZ*

(Continued from May issue)

MEAN PRESSURE INDICATORS

Although the indicator diagram is useful for many other purposes besides the determination of the mean indicated pressure, yet in numerous instances (for example for testing the effect of changing the fuel, shifting the phase of ignition, etc.), this latter quantity is of the chief interest.

For this reason several efforts were made to develop an instrument which would give directly the indicated mean pressure, without the necessity of taking and planimetering the diagram. Although few of these instruments have been developed, up till now, beyond the experimental stage, yet they merit a brief description in view of the interesting principles involved.

If a space of variable pressure is brought into communication with a pressure gage having a high inertia of moving parts (i.e. long natural period of vibration in comparison with the period of the pressure change), then these latter are unable to follow the rapidly changing pressures and assume a position of rest corresponding to a certain mean pressure. The same effect is accomplished by an intensive damping, for example by means of a restricted opening between the tested space and the pressure gage, or by means of a dashpot. This mean pressure will be, however, a time-average of pressures:

$$p_i = \frac{\int_{t_1}^{t_2} p\,dt}{t_2 - t_1}$$

and not the quantity understood under the term of indicated mean pressure, which is a stroke-average of the varying pressures:

$$p_i = \frac{\int_0^s p\,ds}{s}$$

Nevertheless, in a given type of engine, if the engine is working regularly, the time average of pressures furnishes a measure of the load on the engine. The correlation between the time-average and the stroke-average of pressures can be found by experiment for a given engine, by means of taking pressure-time and pressure-stroke cards, and plotting the indicated mean pressure as a function of the time-average of pressures at different loads on the engine. In Fig. 109 this procedure is shown. The plot is approximately a straight line, having a characteristic initial point and a characteristic slope for a given type of engine. It has to be emphasized, however, that this relationship holds good only as long as the original engine conditions (spark setting, fuel injection timing of an internal combustion engine, or the admission pressure of a steam engine) do not change, or if the original valve setting does not become deranged. In other words by this method the indicated mean pressure is not measured as such, but only by inference.

*Asst. Prof. of Engineering Research, Pennsylvania State College.

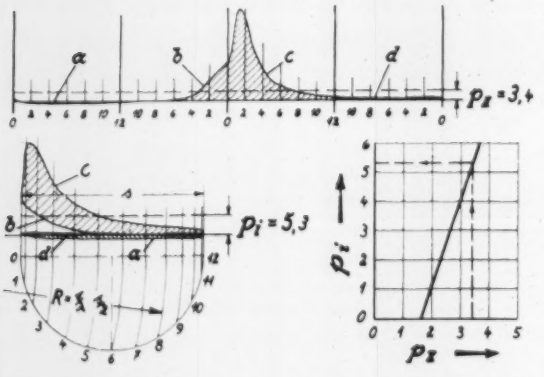


Fig. 109. Correlation between pressure-crank angle and pressure-stroke diagram, showing linear function between p_z (mean pressure on crank-angle basis) and p_i (mean pressure on stroke basis).

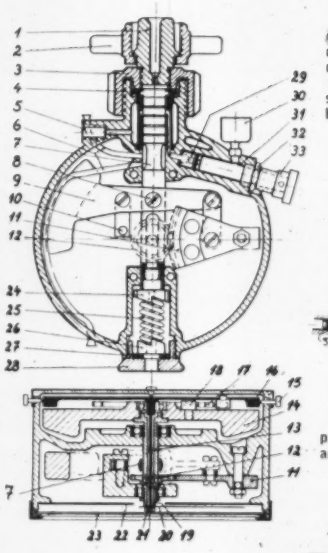


Fig. 110 (left). Mean pressure indicator (Pimeter) of Dr. Geiger (Lehmann und Michels). (1) connection to engine cylinder, with calibrated restricting orifice; (7) piston and rod; (25) loading spring; (16) inertia wheel; (29-33) lubricator; (5) cooling water connection.

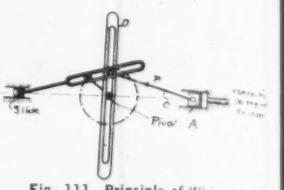
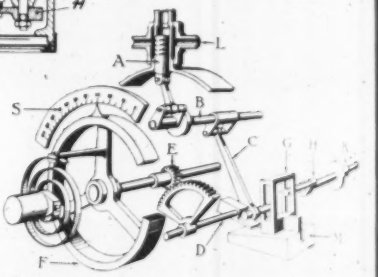


Fig. 111. Principle of Wimperis' mean pressure indicator; Fig. 111a (below) actual construction of instrument.



The so-called Pimeter of Dr. Jos. Geiger[31] (Lehmann & Michels) is based on this principle. (See Fig. 110) The pressures act on a spring loaded piston—similar to a normal indicator piston and spring assembly—the axial displacement of which is communicated to a pointer moving above a graduated dial. The displacement of the piston is proportional to the time-average of pressures, but the dial is calibrated to show the corresponding indicated mean pressure of a given type of engine. As steadying means both damping (a restricted orifice) and inertia (a heavy flywheel) are employed which render the instrument usable from a lowest speed limit of 80 r.p.m. upwards. This instrument has proved useful for numerous test purposes, especially for checking the equality of load distribution in multi-cylindered engines.

The true indicated mean pressure cannot be determined from the pressures alone, but the piston stroke or crank angle phase, at which the pressures occur, also has to be taken into consideration.

The mean pressure indicator of H. E. Wimperis[32] makes use of the fact that the indicated mean pressure

[31] The Wimperis Mean Pressure Indicator. *The Engineer*, Vol. 135, March 2, 1923, pages 238-239.
Geiger. Mitteldruckindikator. *Zeitschrift des Vereines deutscher Ingenieure*, Vol. 70, April 10, 1926, pages 509-512.

p_i and the mean specific (i.e. per unit of piston area) tangential force τ_m acting upon the crankpin are in a definite relationship to each other:

$$\mathcal{L}\, r\, p_i = \mathcal{L}\, r\, \pi\, \tau_m$$

$$p_i = \pi\, \tau_m$$

The mean specific tangential force can be defined:

$$\tau_m = \frac{1}{2\pi}\int_0^{2\pi} \tau\, d\alpha$$

Denoting $\frac{d\alpha}{dt} = \omega =$ angular velocity of the crankshaft, and $\frac{2\pi}{\omega} = T =$ time of one revolution, it can be written:

$$\tau_m = \frac{1}{T}\int_0^{T} \tau\, dt$$

The mean specific tangential force is, therefore, a time-average of the varying specific tangential forces, and as such, it can be determined with the aid of a force-measuring device of sufficiently low natural period of vibration.

In the Wimperis indicator (schematic sketch: Fig. 111) the pressures act upon an indicator piston A and the resulting force P is communicated to a bar D pivoted around its middle, by means of a long connecting rod, C. The point of application of P on the bar is oscillated, by means of a positive drive from the engine, in such a manner that the leverage of P on the bar D is at all times proportional to the leverage of the connecting rod force of the engine. For this reason the torque on the bar pivot will be proportional to the torque on the engine crankshaft. Under the influence of the time-average of this variable torque the bar D is deflected against the spring force acting on a heavy inertia wheel F which latter carries a pointer moving over a calibrated scale. A layout of the apparatus is shown in Fig. 111a.

The mean pressure indicator of E. Schimanek[32] developed in the Hungarian University of Technical Sciences, Budapest, is based on the measuring the torque of a miniature engine—called the measuring engine—the cylinder space of which is brought into communication with the engine cylinder to be tested, and the crankshaft of which is driven in unison with the engine crankshaft. The torque is measured by means of an epicyclic gear dynamometer. In two readings the no-load torque and the load-torque of the measuring engine are determined and their difference gives the indicated torque which is proportional to the indicated mean pressure of the engine.

The instrument is shown schematically in Fig. 112a. If the cylinder space *a* of the measuring engine is brought into communication,—by means of the three-way cock—with the atmosphere, and its piston is oscillated —by means of the planet-gear *f, d, e,* and the adjoining crank-drive—in unison with the engine piston, then the no-load work produces a torque on the lever *h*, in which the middle-wheel *d* of the planet gear is pivoted. This torque can be measured by means of the pressure gage *i* (Fig. 112b) which registers a pressure: p_1. In order to avoid even a minute displacement of the lever arm *h* (and thereby a disphasement of the drive) the lever *h* can be arranged to actuate a piston valve *k* (Fig. 112c) which admits oil under pressure from the reservoir *l* into the pressure gage *m*. If the lever force diminishes, the piston-valve is displaced to the left and oil passes out from the pressure gage into the atmosphere, until the pressure in the gage sinks and the piston-valve *k*, together with the lever *h* return to their respective positions of rest. The pressure reservoir *l* can be considered as a servomotor for bringing back the lever *h* into its position of rest, corresponding to that position of the middle wheel *d* at which the measuring piston is exactly in phase with the engine piston.

[32] Messung des mittleren indizierten Kolbendruckes. *Zeitschrift des Vereines deutscher Ingenieure*, Vol. 70, Apr. 10, 1926, pages 513-514.

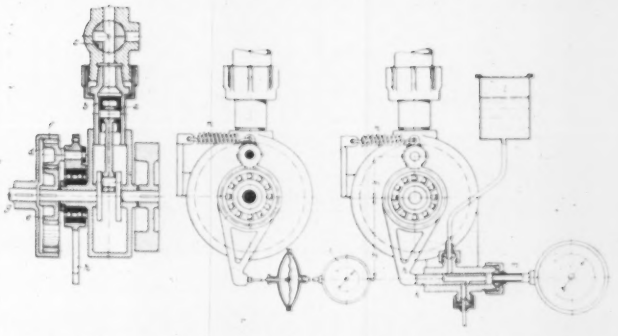


Fig. 112 a, b, c. Principle of Schimanek's mean pressure indicator; *a* measuring cylinder; *b* piston; *c* three-way cock; *d, e, f,* planetary gearing; *g* shaft connected to engine; *h* lever for transferring of force to pressure gage; *i* pressure gage; *k* piston valve; *l* pressure reservoir; *m* oil space for pressure cell; *n* return spring.

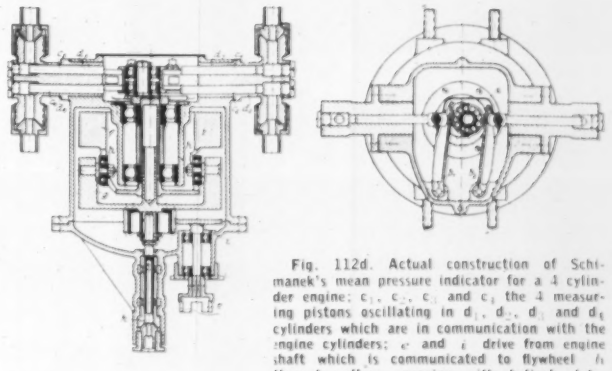


Fig. 112d. Actual construction of Schimanek's mean pressure indicator for a 4 cylinder engine; c_1, c_2, c_3 and c_4 the 4 measuring pistons oscillating in d_1, d_2, d_3 and d_4 cylinders which are in communication with the engine cylinders; *e* and *i* drive from engine shaft which is communicated to flywheel *h* through rollers engaging with helical slots, *h* ; *k* oil space of piston valve; b_1 and b_2 rocker arms with which the pistons are kept in contact by means of horse shoe-shaped spring *a*.

In a second measurement the measuring cylinder is brought into communication with the engine cylinder under test and another reading is taken: p_2. The two lever-forces so obtained are opposite to one another, but on the pressure gage there will be always a positive pressure produced, owing to the action of the spring *n*.

The indicated pressure in the engine can be expressed:

$$p_i = C\,(p_2 - p_1)$$

where:

$$C = \frac{x}{y}\left(\frac{d_1}{d_2}\right)^2 \frac{D\pi}{s}$$

In this equation $\frac{x}{y}$ is the lever ratio shown on the drawing: d_1 and d_2 are the diameter of the indicator piston and the piston valve respectively; $D\pi$ is the pitch circumference of the wheel *e* and *s* is the stroke of the indicator piston.

Figs. 112d shows a unit intended for indicating all the cylinders of a four cylinder engine, which consequently has four pistons acting upon one common crankpin, by means of rockers b_1 and b_2. In this design the function of the lever *h* is performed by helical grooves in coöperation with the rollers *h*, between which an axial force is brought into play which actuates the piston valve. The drive from the engine is transmitted by means of the gear *i* in coöperation with a wide tooth wheel on the flywheel shaft, permitting an axial displacement of the latter.

Control of Fractional-Horsepower Motors

By F. L. SPANGLER*

(Continued from May issue)

Magnetically Operated Reversing Switches

The magnetic reversing switch, on the other hand, provides no-voltage protection—that is, when the switch opens because of a temporary loss of line voltage, it does not reclose upon return of voltage until either the "Forward" or "Reverse" push button is pressed. Connections of this type of switch for series-wound and shunt-wound motors are shown in Fig. 18. The scheme of connections for reversing switches with 3 poles is shown in Fig. 19.

It is important with reversing switches to prevent the closing of one switch until the other is fully open, since with both switches closed at the same time, the line would be short-circuited. Therefore, in addition to electrical interlocks supplied with these switches to prevent the hold-in coil of either switch from being energized except when the other switch is fully open, these switches are also mechanically interlocked so that it is impossible for both switches to be closed at the same instant.

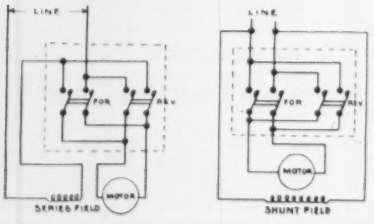


Fig. 18. Scheme of connections for switch shown in Fig. 20 when used for controlling a.c. and d.c. commutator type motors.

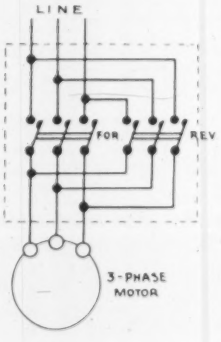


Fig. 19. (right) For starting and reversing 3-phase squirrel-cage motors, switches must have 3 poles if all the motor leads are to be opened.

The reversing switch shown in Fig. 20 has two double-pole magnetic switches mounted back to back with a horizontal interlocking pin between them. When the switch on one side closes, it pushes the interlocking pin forward against the arm of the opposite switch. If the opposite switch is already closed, the interlocking pin cannot move forward and the first switch remains open. If the opposite switch is not closed, the interlocking pin can slide forward and permit the first switch to close.

Magnetic reversing switches may be controlled by push button master switches. When the motor is operated for only a few seconds at infrequent intervals, control can be had by using a "Forward" and a "Reverse" button, in which case the motor operates only as long as one of the buttons is held down, and as soon as the button is released the magnetic switch opens and disconnects the motor from the line. This is equivalent

*Industrial Engineer, Allen-Bradley Co.

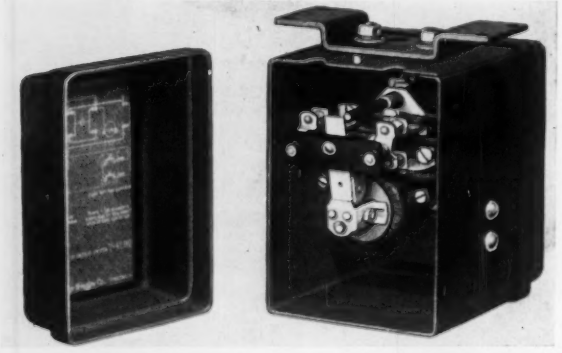
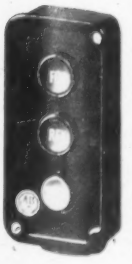


Fig. 20. This reversing switch consists of 2 magnetic switches mounted back to back and controlled through push buttons, limit switches, reversing drums, or other types of pilot devices. One of these switches provides forward direction of rotation and the other provides reverse direction.

Fig. 21. Push-button pilot control station for the control of magnetic reversing switches like that shown in Fig. 20.



to 2-wire control, and the hold-in circuit with interlock is not required on the magnetic switches.

Where the duration of operation of the motor is longer, the master control station is furnished with 3 buttons designated "Forward," "Reverse," and "Stop," as shown in Fig. 21. The diagram of connections of a magnetic reversing switch operated by a three-button station is shown in Fig. 22. This diagram includes auxiliary control through two limit switches, which type of control has many different applications. Used in connection with a device for opening and closing doors, for example, the push buttons can be designated "Close," "Open," and "Stop." When the door is closed it opens one of the limit switches and when the door is fully opened the other limit switch is open. The use of the limit switches gives complete protection against overtravel of the door. If the door is of the fire-proof type and is a part of a fire wall, a device actuated by the heat or light from a blaze can be made to close the door by the closing of a contact which connects terminal C1 to terminal C2 (see Fig. 22), thereby causing the "Forward" or "Close" switch to operate.

If it is desirable to operate the door from either side, 2 master push-button stations must be provided and connected together as shown in the diagram in the upper right hand corner of Fig. 22. These switches can be installed in separate rooms.

When the motor is operating, and its direction of rotation is changed by pressing either the "Forward" or "Reverse" button, the button performs two functions. As the button is pressed in, it first opens the circuit to the hold-in coil of the closed switch, causing the switch to open; and when the button is completely in, it completes the circuit to the hold-in coil of the other switch, causing that switch to close. Each switch is provided with an auxiliary contact in series with the hold-in coil of the other switch. These auxiliary contacts provide the electrical interlock already referred to and make it impossible to energize the hold-in coil of the other switch if the other switch is closed. The push-button station, like the push buttons used with all magnetic switches providing low-voltage protection, is of the momentary-contact type. Each switch has a hold-in contact so the switch when once closed remains closed until the button controlling the other switch is pressed or the "Stop" button is pressed.

Fig. 22 also shows the simple scheme of connections used where a 2-button master control station is employed. This type of control, like that already described, can be connected for operation from two or more push-button stations.

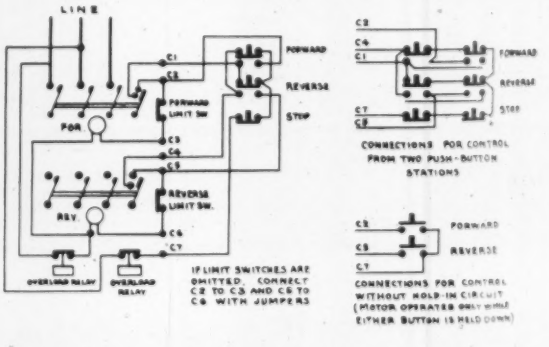

LINE
FORWARD
REVERSE
STOP
FOR
REV
OVERLOAD RELAY
IF LIMIT SWITCHES ARE OMITTED, CONNECT C2 TO C3 AND C6 TO C8 WITH JUMPERS
CONNECTIONS FOR CONTROL FROM TWO PUSH-BUTTON STATIONS
CONNECTIONS FOR CONTROL WITHOUT HOLD-IN CIRCUIT (MOTOR OPERATES ONLY WHILE EITHER BUTTON IS HELD DOWN)

Fig. 22. Diagram of connections of control circuits for magnetic reversing switches and push-button stations.

Motors that cannot be started across-the-line but must employ starting resistors which are shunted out of circuit when the motor comes up to speed, can be reversed by any of the reversing switches mentioned above, if these are used with an automatic resistance-type starter installed in the motor circuit between the reversing switch and the motor. The connection diagram of such a control is shown in Fig. 23.

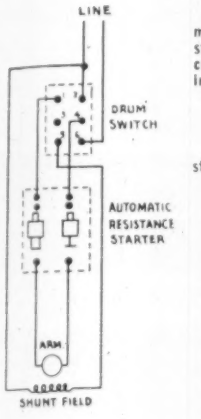
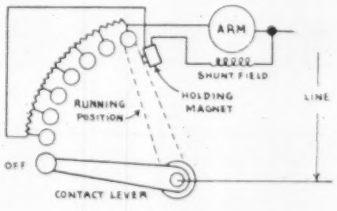


Fig. 23. Where load conditions do not permit across-the-line starting, an automatic starter of the resistance type can be used in connection with a reversing switch for starting, stopping, and reversing the motor.

Fig. 24. Typical face-plate-type rheostat for starting fractional horsepower motors.



Reduced-Voltage Starting

The simplest resistance starter is a face-plate type of rheostat, in which a hand lever is moved over a series of contacts, thereby cutting out successive steps of resistance as the motor comes up to speed. This rheostat is inserted in series with the motor armature and the connections are such that the shunt field is energized as soon as the contact arm is moved to its first point. Thus the motor field is maintained at its full strength as the motor comes up to speed, thereby causing the motor to develop its maximum torque. The connections of a face-plate starting rheostat are shown in Fig. 24. By employing a spring-return handle and a hold-in coil connected in series with the shunt field, the lever automatically returns to its "Off" position should the line voltage fail or if the shunt field is opened. This latter protection is necessary for shunt and compound wound motors, since an open field winding would result in a dangerous speed.

Many manufacturers and users of motor-driven equipment find it expedient to take all responsibility for the proper acceleration of motors away from the operators of the machine. Hence, the face-plate type of starting rheostat which was in common use 10 years ago for starting fractional-horsepower motors has been largely supplanted by the automatic type of starter consisting of a line switch and an accelerating switch, both magnetically operated, as well as a timing relay and a resistor, together with overload relays. A starter of this type for use with small d.c. motors is shown in Fig. 25, in which the accelerating switch and timing relay are combined into one device consisting of an oil-filled dashpot with a plunger actuated by a shunt coil, and overhead contacts which close when the plunger reaches the end of its stroke. The wiring diagram of this switch, connected for control by a pressure switch, float switch, or other type of two-wire pilot device, is shown in Fig. 26. This switch can also be used with 3-wire control through push buttons to give no-voltage protection.

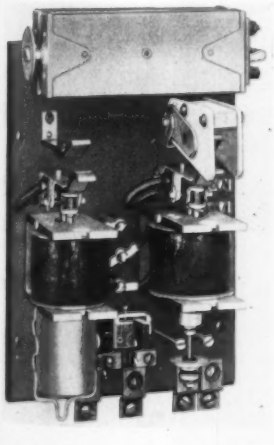


Fig. 25. Automatic resistance-type starter for small d.c. motors. The resistance units are mounted at the top and the overload relay at the bottom of the panel. The switch on the right closes first, starting the motor with resistance in series, and a few seconds later, the switch at the left closes and shunts the resistance out of circuit.

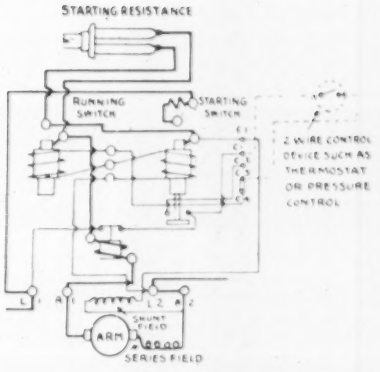


Fig. 26. Connection diagram of automatic starter shown in Fig. 25 for the control of a compound-wound motor through a pressure switch or other 2-wire pilot device.

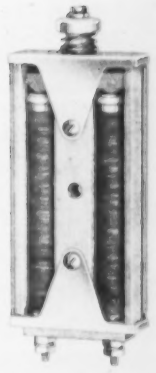


Fig. 27. The graphite compression type of starting resistor is easily adjustable for resistance values to suit the starting load requirements.

When the control circuit is closed, the starting switch closes and connects the motor to the line through the starting resistor. At the same time, the solenoid of the accelerating switch is energized; and after a predetermined time, depending on the setting of the dashpot mechanism, this switch closes and shunts the resistor out of the motor circuit. When the control circuit is open, both the starting and accelerating switches are de-energized, and they open and disconnect the motor from the line. One side of the shunt and series field is always connected to the line, and therefore a disconnect switch must be added to open this lead if complete disconnection of the motor is desired.

Resistors for Motor Starting

The starter shown in Fig. 25 is equipped with a graphite compression resistor similar to that shown in Fig. 27. This resistor consists of 2 parallel columns of small, hard graphite disks, and its resistance can be varied over a wide range of values by applying pressure to the disks through the pressure plug shown mounted on the left of the resistor. For any given installation, the pressure plug is adjusted to give the proper value of resistance to suit the characteristics of the starting load. The motor and line terminals are shown on the right of this resistor. A thermal type of overload relay on the starter panel gives reliable overload protection to the motor during starting as well as while running.

Resistors used for motor starting are in circuit only during the brief starting period and are shunted out of the circuit during the rest of the time the motor is operating. At the instant of starting the motor, the resistor is usually cool, but it heats up while the motor is accelerating because the starting current passes through it. The electric energy it absorbs during the starting period is dissipated in the form of heat. After the motor has attained full speed, the resistor is short-circuited, thereby shunting the motor current around the resistor and allowing the resistor to cool off.

If, however, the motor is started and stopped frequently, the resistor may overheat. When starting is frequent, the resistor must have a higher heat-dissipating capacity than otherwise would be necessary. Therefore, resistance-type starters are given duty ratings which should not be exceeded in service. These ratings are expressed in terms of length of starting period and frequency of starting. For example, a starter complying with American Standard Resistor Classification No. 15 is designed for not greater than 150% normal current inrush and a 15-second starting period every four minutes for one hour. This, as well as other American Standard Resistor Classifications, is based on a maximum room temperature of 40° C. without artificial ventilation of the resistor. Room temperatures are seldom as high as this, so ratings based on these classifications are quite conservative.

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MANUFACTURERS' LITERATURE

In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

A115 **General Catalog with Brewery Supplement.** An impressively bound set totaling 126 pages, the new supplement being classified by applications. C. J. Tagliabue Mfg. Co., Brooklyn, N. Y.

A116 **Photo-Relay.** Circular on beam projector, relay and "Unilet" used not only for counting and other on-and-off applications but for high temperature measurement. Argus Electric Co., St. Charles, Ill.

A117 **Brewer's Optical Instruments.** Bulletin on yeast culture microscope and dipping refractometer. Bausch & Lomb Optical Co., Rochester, N. Y.

A118 **Magnifiers and Readers.** 32-page catalog on general-purpose, watchmaker's, student's, sport and other glasses. Bausch & Lomb Optical Co., Rochester, N. Y.

A119 **Toolmaker's Lathes & Accessories.** 8-page Circular No. 9-G describes latest models. South Bend Lathe Works, South Bend, Ind.

A120 **Filter Paper.** 6-page folder on Munktells Swedish Filter Paper. E. H. Sargent & Co., Chicago.

A121 **Bacteria Count.** Folder on the Stone bacteria colony counter and Universal microscope lamp. Bausch & Lomb Optical Co., Rochester, N. Y.

A122 **Adjustable Orifice.** Folder on variable-orifice primary metering element. Bailey Meter Co., Cleveland, O.

(Continued on Page 122)

Flow Measurement and Control*

By M. F. BEHAR†

CHAPTER XXIII
POSITIVE METERS
(Continued)

8. Positive Gas Meters—General Considerations

(Continued from May)

(e) Low Pressure Flow Provers

These devices are themselves metering elements—in fact, complete meters of the head class and orifice type—and some metermen call them "flow meters," but they are designed for use when discharging to atmosphere and hence, in practice, they are only used as provers. (They are preferably known as provers, the designation "flow meter" being reserved for service meters with rate responding primary elements.)

The term "low pressure" is used to designate that type of flow prover which in use employs an absolute pressure on the upstream side of the orifice of not more than 1.89 times the absolute atmospheric or downstream pressure. That type of prover in which the upstream absolute pressure is more than twice the downstream absolute pressure is known as the "critical flow type," and is dealt with in Art. **(f)**.

Multiple Hole Types

Early forms of low pressure flow provers consisted of mere boxes with a plurality of holes in one or more sides, each hole having a removable plug. These boxes were made into various shapes. One shape, which became the most popular, is a truncated cone with about twenty 1½" holes in its base. Resembling a funnel, it was called a funnel meter. (This name stuck, and even the modern single concentric orifice flow prover is called a funnel meter in some quarters, in spite of the facts that it is not funnel shaped and that it is not used for metering.)

The theory of the multiple-hole prover is that the volume of homogeneous gas discharged to atmosphere per second is directly proportional to the number of unplugged holes of equal size, provided that the following factors remain constant: (1) pressure on meter and hence in prover box, (2) atmospheric pressure, (3) gas temperature, (4) specific gravity of gas.

In order to simplify the procedure and avoid extra calculations, the method of using this type of prover usually consists of determining (2) and (4) before a test, of reading (3) from time to time, and of so regulating the flow that pressure (1) will not only be constant but will be exactly that required to cause a discharge of 1 cu. ft. per second through one standard hole, or 5 cu. ft. per second through 5 holes, or some other even figure. A sensitive water column manometer is the only instrument that has to be watched constantly.

This requires, of course, that the pressure corresponding to the 1 cu. ft. per second discharge through one 1½" hole be given. The industry has for years used the equation

$$p = \frac{B \times G}{0.0138 \times T}$$

in which p is inches of water, B the corrected barometer reading in inches of mercury, G the specific gravity referred to air and T the temperature in °F. abs.; and numerous tables have been printed to relieve metermen from all mathematical work. For years the procedure just described, and modifications thereof, have been used with fair satisfaction, and are still "good enough" for detecting very fast or very slow meters.

The coming of accurate meters for industrial service has made the multiple hole prover somewhat obsolete. The trouble is that accurate results cannot be obtained without including the velocity of approach factor. As will be ex-

*Part Six of *The Manual of Instrumentation.*
†Editor, *Instruments.*

plained in Chap. XXV, this means that the simple formula given above cannot be relied on. In other words, pulling holes in and out varies the approach factor, so that (1) the sum of the given discharges does not equal the actual total discharge, and (2) the coefficients vary with the particular holes. To put it in another way, two "1800" holes seldom give "3600" and each "1800" hole would pass a different rate depending on which other holes were being pulled out.

In addition to uncertain effects with different combinations of holes, the edges of the holes are hard to maintain in good condition and errors creep in from this cause. Finally, the effects of varying wind velocities on the discharge stream introduce one more element of uncertainty.

Single Orifice Type

This consists essentially of a long straight tube in two sections, a set of interchangeable orifice plates, and provisions for accurately measuring the gas pressure and temperature. Knowledge of the specific gravity is required but a gas balance is not part of the equipment. The prover is in fact a concentric orifice meter differing from those discussed in Chap. XXV in that the differential across the orifice corresponds to the upstream pressure. Most readers could make a prover of this type out of odds and ends, but the author strongly recommends against such practice except where accuracy is not required. Inasmuch as a meter prover is desired to be more accurate than the meters to be calibrated, and inasmuch as modern industrial positive meters can be accurate to within 0.5%, it pays to use one of the available makes of provers embodying useful refinements resulting from specialized experience.

The prover is either attached directly to the outlet of the meter, where it is possible to cut out of service the meter to be tested; or in case where it is possible to by-pass the meter (and industrial meters are preferably installed in this manner) attach the prover to a test tee directly at the outlet of the meter to be tested. A small orifice in the coupling or between the flanges of the prover should be used for the check rate test. For the open rate a larger orifice is then used. Precaution should be taken that there are no leaks in any of the fittings between the inlet of the meter and the gate at the outlet of the test tee. Also, there should be no leak in the outlet gate causing a back flow and an error in the test. Either a plug valve, or two gate valves with a release to atmosphere between them, should be used on the outlet of the test tee for a complete shut off.

An assortment of orifice plates of various sizes from 1/8 up to 6/10 the inside diameter of the tube is an important part of the outfit. Each plate is stamped with its standard rate, *i.e.*, the rate with standard pressure maintained in the prover when atmospheric pressure and gas temperature and gravity are standard. Tables are provided whereby the user can compensate or correct for divergences from standard conditions not under his control. All the meterman need do, after properly attaching the prover, testing for leaks with soapsuds, etc., is to consult tables (or curves) and adjust the water pressure accordingly.

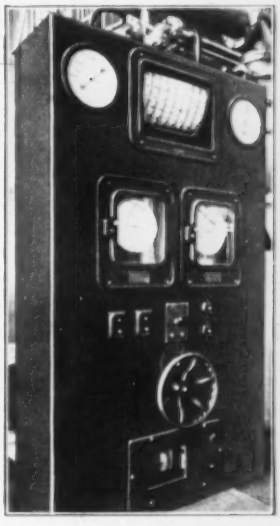
A good stopwatch makes it possible to shorten the duration of each test. Wherever a meter is to be proved at as many rates as there are orifices, this saves much of the time the meter is out of service.

Perhaps the most important part of the outfit, however, is the manometer. Inasmuch as the usual standard pressure is 4″ of water, a precision grade instrument is required. The connection—particularly the tap where the prover pressure is taken off—should be such that the true static pressure is measured, and that no velocity or kinetic effects introduce errors.

The usual proving procedure consists of following the directions and comparing the stopwatch reading of meter registration of a given volume with each orifice time to obtain the error time for each orifice—that is to say for each flow rate or meter load. Generally, the check and open flows are found first and the intermediate points later. Any meterman can do it. However, an engineer equipped with an orifice flow prover and the maker's complete tables and coefficients, and capable of making his own computations, can use higher or lower manometer pressures and can therefore test industrial low-pressure meters under conditions reproducing those of service. He can also apply Boyle's law in cases where the pressure on the meter is more than that just ahead of the prover orifice—which is important in those cases because the meter under test is purely volumetric while the prover is inferential and hence affected by the density factor.

Fig. 23-58 shows the "Emco" Flow Prover and the "Emconometer" precision water manometer (Pittsburgh Equitable Meter Co.), an outfit brought out in 1933. Among its features may be mentioned a correctly designed piezometer ring form of pressure tap, which does away with velocity errors. The manome-

FOR BOILER CONTROL



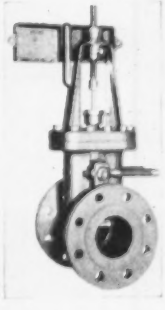
THE BAILEY BOILER PANEL gives complete information for controlling boiler operation. It contains the Bailey Boiler Meter, a Bailey Fluid Meter with which is combined a Boiler Water Level Recorder, and a Bailey Multi-Pointer Gage. The operator has everything right before him to obtain the desired capacity and best efficiency at all times. Request recommendations for your boilers.

PRESSURE GAGE

Extremely accurate gages embodying the dead weight gage tester principle are available in several sizes up to 36″ in diameter for indicating at remote points the pressure of steam, water, gas, etc. These gages can be used with any pressures and are particularly suitable for magnified ranges. Ask for Bulletin No. 70.

LONG DISTANCE INDICATOR

Bailey Meter Selsyn Operated Equipment for recording and indicating pressure, temperature, draft, liquid level, etc. at any distance from the source is highly accurate and reliable. Described in Bulletin No. 110.



ADJUSTABLE ORIFICE

The Bailey Adjustable Orifice is for use with Fluid Meter installations where accurate measurements are desired over a flow range of as wide as 160 to 1. Ask for details.

BAILEY METER CO.
1041 IVANHOE ROAD
CLEVELAND, OHIO

A123 **Water Supply and Sewage Metering.** 32-page catalog on complete line of meters for sewage treatment and water supply. Bailey Meter Co., Cleveland, O.

A124 **Portable Hardness Tester.** 2-sheet bulletin on testing hardness of wire with the Duroscop. R. Y. Ferner Co., Washington, D. C.

A125 **Pyrometers.** Two folders on new line of thermoelectric pyrometers. Mishawaka Industrial Instrument Manufacturing Laboratory, Mishawaka, Ind.

A126 **Miniature Steam Generators.** 4-page bulletin on laboratory steam generators. Commonwealth Elec. & Mfg. Co., Boston.

A127 **Mercury Arc Rectifiers.** 16-page Circular 1907-B on sectional steel-tank type rectifiers for railroad and industrial uses. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

A128 **Load Testing Devices.** 24-page catalog of load testing equipment for a.c. circuits, multirange a.c. indicating ammeters, phantom loads, etc. Western Electro-mechanical Co., Oakland, Calif.

A129 **The Experimenter.** Among articles in April-May 1933 issue is one by R. F. Field on "The Convenient Measurement of *C*, *R* and *L*." General Radio Co., Cambridge, Mass.

A130 **Airplane Instruments.** 6-page circular on thermometers, pressure gages and new Triple Service Engine Unit. Consolidated Ashcroft Hancock Co., Bridgeport, Conn.

A131 **Recorder-controller.** 8-page Catalog 2510 on the Controlograph for recording and controlling temperature or pressure. Consolidated Ashcroft Hancock Co., Bridgeport, Conn.

A132 **CO_2 Recorders.** Two bulletins on new stationary and portable models of 1-, 2- and 3-pen CO_2 recorders. Defender Automatic Regulator Co., St. Louis, Mo.

A133 **Control Devices.** 14 new loose-leaf pages for the catalog of Automatic Temperature Control Co., Inc., Philadelphia.

A134 **Humidity Control.** Circular on new model open-contact low-voltage Humitrol. Lewis Air Conditioners, Inc., Minneapolis, Minn.

A135 **Photomicrography.** 8-page bulletin on low-power photo-micrography with Micro Tessar lenses. Bausch & Lomb Optical Co., Rochester, N. Y.

A136 **Bausch & Lomb Magazine.** April 1933 issue contains an article on the Century of Progress Exposition. Bausch & Lomb Optical Co., Rochester, N. Y.

A137 **Temperature Control.** Leaflet on extremely sensitive Beckmann thermometer type regulator. Hiergesell Hiergesell Bros., Philadelphia.

A138 **Electrical and Industrial Instruments.** Catalog "B" shows several new items such as Type TP-1 current transformer and short-circuit-proof ammeters. Herman H. Sticht & Co., New York.

A139 **Relays.** Folder on "Dunco" relays. Also circular on new hot wire time delay designed for delays from 1 to 5 seconds. Struthers Dunn, Inc., Philadelphia.

A140 **Telemetering and Totalizing Station Loads.** 16-page Bulletin No. 874, on means for providing the load dispatcher with continuous information on load conditions throughout the system, to facilitate load distribution in ordinary conditions, and to aid in control of emergencies. Comprehensive explanation of the method employed. Leeds & Northrup Co., Philadelphia.

A141 **Solution Feeder.** Loose-leaf engineering data sheets on chemical solution feeding machine. Phipps & Bird, Inc., Richmond, Va.

A142 **Taylor Rochester.** April 1933 issue runs to 78 pages and contains a number of meteorological articles. Taylor Instrument Companies, Rochester, N. Y.

A143 **D. C. Amplifier.** Circular on improved d.c. amplifier equipped with string galvanometer. Allen B. DuMont Laboratories, Upper Montclair, N. J.

A144 **Oscillography Equipment.** 4-page bulletin on cathode ray tube oscillographs and accessories. Allen B. DuMont Laboratories, Upper Montclair, N. J.

A145 **Ohmite News.** April 1933 issue includes engineering data on voltage dividers. Ohmite Mfg. Co., Chicago.

A146 **Radio Instruments, etc.** Data sheets on the "Multidapter," on a new tube checker and on a new "Multitester." Radio City Products Co., New York.

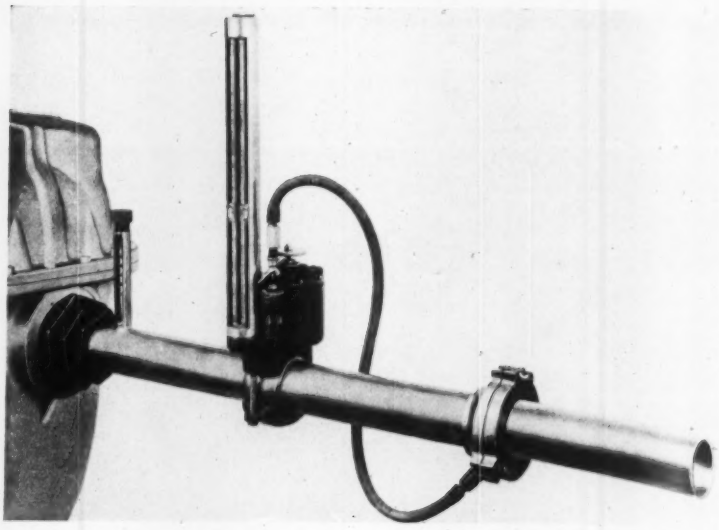


Fig. 23-58

ter, a highly developed instrument, is mounted by means of a universal joint which allows it to be leveled. It consists essentially of a tube of large diameter (to eliminate any uncertain meniscus effects) attached to a small water reservoir. When pressure is applied to the pressure tap on the reservoir, the water will rise in the pressure indicating tube, but due to the small diameter of the reservoir, the level will fall by the amount of fluid drawn from the reservoir into the pressure tube. Since it is impractical to use a reservoir with a diameter large enough to eliminate any zero error due to the drop in the reservoir and at the same time use a large enough tube, it is necessary to compensate for this drop and this is accomplished by screwing the adjusting wheel on top of the reservoir until the water level in a "sight tube" (adjacent to the pressure tube) returns to its original zero mark. A reading between the meniscus in the two tubes gives a true pressure reading. A slider is mounted on an accurately cut scale divided in 50ths, and a mirror is provided to eliminate errors of parallax.

The American Meter Co.'s low pressure 2″ flow prover is illustrated in Figs. 23-59 and 23-60 which are self-explanatory. Their 4″ flow prover is similar but is not furnished as a "kit" in a carrying case.

Fig. 23-59

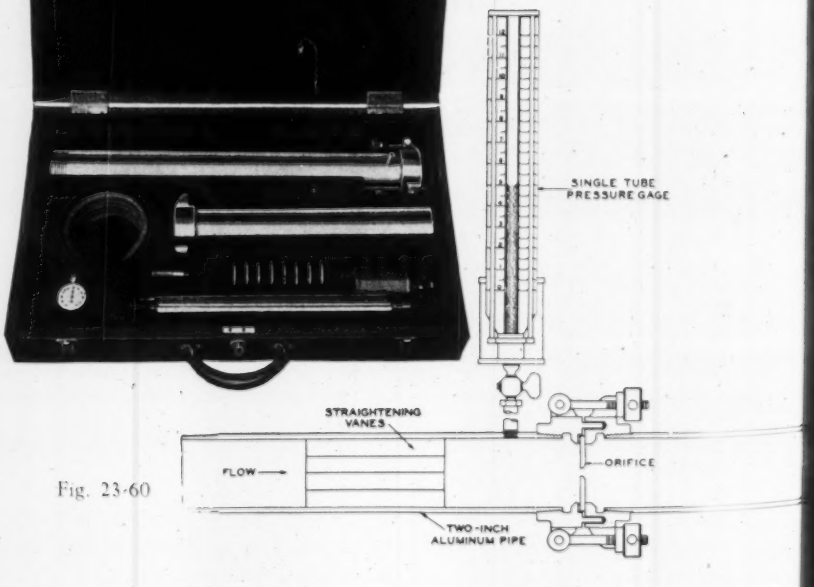


Fig. 23-60

(*f*) Pierce Critical Flow Prover*

This is the most suitable type of portable standard for testing high-pressure positive meters under working conditions in the field where a small amount of gas can be wasted into the atmosphere. If the proof of the high-pressure meter does not change with changes in pressure (and it should not), the time required for the full circle reading of the proving hand index should be the same for any particular orifice and kind of gas, regardless of variation in pressure. In other words, it is possible, with this prover, to test a meter at any particular index rate, regardless of the variation in line pressure or atmospheric pressure, if the line pressure is 15 lb gage or more.

All factors pertaining to pressure are eliminated. For example, a ¼″ orifice will pass 800 cu. ft. of air per hour (index reading) if the line pressure is 15 lb, and likewise, the same orifice will pass 800 cu. ft. of air per hour (index reading) if the line pressure is 100 lb. The meter is tested under working pressure conditions by attaching the orifice to a connection close to the outlet of the meter, without any restrictions between the meter and the prover.

The theory is as follows: When any gas passes through a round-edge orifice and the down-stream pressure is less than one-half of the up-stream pressure, it is assumed that the velocity of each particle of gas at line pressure attains the velocity of sound. Based on this principle, the formula for obtaining the correct time for the passage of M cu. ft. of gas (index reading) through a meter and a critical flow orifice is:

$$t_g = Mt_a \sqrt{\frac{520\, k_a\, G}{k\, T}}$$

in which

t_g = correct time in seconds for M cu. ft. of gas (index reading) at line pressure and line temperature.
M = index reading.
t_a = time in seconds for 1 cu. ft. (index reading) of air at a 60° F. (obtained by calibration against a standard).
520 = absolute temperature corresponding to 60°F.
k_a = ratio of specific heats of air.
k = ratio of specific heats of gas.
G = specific gravity of the gas.
T = absolute temperature of gas, °F.

The quantity of air which passes through the critical flow orifice in a second, expressed in cu. ft. at the up-stream pressure and temperature,

$$\mathcal{Q}_a = \frac{1}{t_a N}, \text{ in which}$$

t_a = standard air time of the orifice in sec. cu. ft.
N = factor for temperature, and ratio of specific heats (obtained from tables).

If the standard air time of an orifice is 4.50 sec. and the temperature is 70°, the time for 1 cu. ft. of the air at line pressure and line temperature is 4.50 × 0.990, or 4.46 sec. The quantity which will pass through the orifice in a second at line pressure and temperature is equal to 1 ÷ 4.46, or 0.2242 cu. ft.

If it is desired to express the quantity of gas a second in cu. ft. at base temperature, T_b and base pressure, P_b the above formula may be written

$$\mathcal{Q} = \frac{P\, T_b}{t_a\, T N G_f P_b}, \text{ in which}$$

$\mathcal{Q}$ = cubic feet a second at base pressure, P_b, and base temperature, T_b.
t_a = standard air time of the orifice; seconds for 1 cu. ft. at 60°F. (520°F. abs.).
P = absolute up-stream pressure in the same units in which the base pressure is expressed.
T = up-stream temperature in °F. abs.
N = factor for temperature and ratio of specific heats, from tables.
T_b = base temperature in °F. abs.
G_f = factor for specific gravity of gas, from tables.
P_b = absolute base pressure in the same units in which the up-stream pressure is expressed.

A small orifice is used for a test at a low rate of flow, and a larger orifice for tests at higher rates of flow. The table herewith gives the approximate index rates in cu. ft. per hour at meter pressure, for orifices of various diameters, also the approximate time required for the passage of 1 cu. ft. of air and time required for the passage of 1 cu. ft. of gas. This table is used to determine the sizes of orifices required for proof tests. A 0.500″ orifice should

*Adapted from Diehl's *Positive Displacement Gas Meters* and publications of American Meter Co.

A147 **Temperature & Pressure Control.** 8-page announcement and description of new Dubl-Response Regulators. Taylor Instrument Companies, Rochester, N. Y.

A148 **Relays.** Bulletin 361 on motor-driven time-delay relays; Bulletin 371 on "Agastat" pneumatic time-delay relay. Ward Leonard Elec. Co., Mt. Vernon, N. Y.

A149 **Comparator.** Bulletin on new frictionless precision comparator eliminating human equation. Precision Gage & Tool Co., Dayton, O.

A150 **Industrial Weight Recorders.** Catalogs M32, R32 and I32 on automatic (printing) weight recorders for various industrial applications. Streeter-Amet Co., Chicago.

A151 **Notes on Current Meters.** Illustrated folder on latest models of Hoff current meters. Scientific Instrument Co., Berkeley, Calif.

A152 **Combustion Control.** Three new 16-page bulletins (in German) on boiler control systems and other regulating devices. American Askania Corp., Chicago.

A153 **Special Bargain Prices** is the sub-title of Stock Bulletin 43-000 Supplement 1, listing hundreds of electrical instruments many of which are priced below production cost—inactive items but in 1st class condition. Westinghouse Elec. & Mfg. Co., Newark, N. J.

A154 **Laboratory Supplies.** 6-page bulletin on Sargent Quinhydrone Acid pH Meter; 8-page catalog of laboratory gas burners; leaflet on "Precision" Solar Evaporator and various fittings. E. H. Sargent & Co., Chicago.

A155 **Draft Gages.** A descriptive folder on portable inclined tube draft gages and CO_2 indicators. F. W. Dwyer Mfg. Co., Chicago, Ill.

A156 **Time Delay Unit.** Bulletin P 38 gives a detailed description of the Time Delay unit. Struthers Dunn, Inc., Philadelphia, Pa.

A157 **Experimenter.** No. 10, March 1933 of this publication features the article, "Mixer Circuits that work." General Radio Co., Cambridge, Mass.

A158 **Rotax Controller.** Bulletin No. 184 describes the "Rotax" electrically operated controller with rotating contacts used for temperature, pressure, humidity and liquid level. The Foxboro Company, Foxboro, Mass.

A159 **Temperature Control Instruments.** No. 3000-c, a new 32-page illustrated bulletin describing in detail Mason-Neilan Compensated Temperature Control Instruments. Neilan Co., Ltd., Los Angeles, Calif.

A160 **The Deoscillator.** A loose-leaf pamphlet featuring The Deoscillator, a new development for improving the operation of two-position pyrometer control. The Foxboro Co., Foxboro, Mass.

A161 **Colorimetry and Nephelometry.** A 15 page book identified as Section E 33 is devoted to colorimetry and nephelometry. P. J. Kipp & Zonen, Delft, Holland.

A162 **Gas Meters.** The Lambert Meter Company, Bush Terminal Building, No. 4, Brooklyn, N. Y., have issued a 20-page booklet on gas meters and apparatus.

A163 **Photo Electric Cells** made by the Continental Electric Co., St. Charles, Ill., are described in a 4-page folder.

A164 **Hand Tachometers.** Circular No. 106 describes the new Automatic Fixed Reading Tachometer for speed measurement of revolving equipment as motors, pulley shafts, belt surfaces, etc. Amthor Testing Instrument Co., Inc., Brooklyn, N. Y.

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INSTRUMENTS BOOK SHELF

Optical Pyrometry. (Encyclopédie Photométrique. 5ème Section—Mesures sur l'Emission. IV—Traité de Pyrométrie Optique). By GUSTAVE RIBAUD. Preface by CHARLES FABRY. Paris 1931: Editions de la Revue d'Optique Théorique et Instrumentale. Cloth, 6¼ x 9½ inches, xvi + 485 pages. 163 figs., 72 extratextual tables. Price 95 francs.

Here at last is the first full-length book on optical pyrometry. It runs to half a thousand pages and treats radiation pyrometry and other topics not covered by the title.

Such a work as this does not miraculously spring full-fledged from one man's brain. Back of it there must be years of arduous research not only by the author himself but by a group of physicists and laboratory technicians working under his direction. In this case the back-of-the scenes explanation is that Prof. Ribaud is the Director of the Pyrometric Laboratory of the Edmond de Rothschild Foundation. Since 1919 this Foundation has endowed French pyrometric research and back of *this* we may discern Rothschild's patriotic striving to restore to France the primacy in the field of pyrometry which she enjoyed in the eighties and nineties. For was it not Le Châtelier who founded optical pyrometry exactly 40 years ago?

In his first chapter, on high-temperature pyrometry, Prof. Ribaud sets forth the reasons for discarding the instruments which made it possible to define the temperature scale up to the gold point, in favor of optical methods, giving at the outset the experimental bases for rejecting the Stefan-Boltzmann law and adopting the Wien-Planck law for fixing the international scale above 1063° C. This chapter ends with a typographic visualization of the international scale, the means for its realization, etc.

The second chapter defines and discusses the various magnitudes involved and their relations. The symbols and the terms themselves are those adopted at the Illumination Congress of 1924 and declared by the author to be official, but some of them differ from those used in American pyrometric literature. Chap. III deals with optical properties of bodies, with the black body and Kirchhoff's law. In Chap. IV, on the laws and the values of the constants of the black body, the author avoids theoretical development of these laws but sticks to the physical aspects, giving a helpful comparison of the Wein and Planck formulas, sources of error, etc.

Credit is given to American investigators in Chap. V on the experimental verifications of black body radiation laws and of C_2, and their instruments described in detail. Even more fully illustrated is Chap. VI, on emissivity of non-black bodies, which runs to 31 pages and ends up with the calculation of the true temperature of a metal and with a discussion of the gray body, which he declares non-existent in the form of actual materials and difficult to realize—which is news to many of us! Chap. VII describes all methods of measuring color temperatures and compares the results obtained. Chap. VIII deals entirely with color temperature, the author adopting this American term, reporting all important researches and comparing their results with one another. In this field, too, he credits Hyde, Forsythe and other Americans, but he also contributes a further advance in the form of his simplified law for the curve of the reciprocal of color temperatures, which is of practical value in permitting pyrometricians to determine whether a given source *has* a color temperature.

Chaps. VIII and IX continue with non-black bodies, the former mainly with total radiation and the latter with monochromatic intensity and other luminous properties. Chap. X, on the optical pyrometer as an instrument of extrapolation, is mostly a critical study of adaptation of brightness reduction systems to the special case of pyrometry. The flicker or sector disk system

(Continued on Page 130)

APPROXIMATE CAPACITIES OF CRITICAL FLOW ORIFICES
(American Meter Co.)

Orifice diameter, inch	Air Time for 1 cu. ft. index reading, seconds	Cu. ft. air per hour, index reading	Cu. ft. air (G = 0.6) per hour, index reading
0.125	18.00	200	250
0.250	4.50	800	1000
0.375	2.00	1800	2250
0.500	1.13	3200	4000
0.625	0.75	4800	6000

be used for testing a meter at a rate of 4000 cu. ft. (index reading) an hour. A 0.250" orifice may be used for a low rate test. The only factors which affect the test are the time required for a definite meter-index reading, the temperature of the gas at the meter, the specific gravity of the gas, and the ratio of specific heats of the gas, which may be assumed to be a constant for any particular gas. In cases where the specific gravity varies from time to time during the day, or where the ratio of specific heats may vary, a simple procedure has been devised for testing by this method. This procedure involves the use of one small high-pressure meter in addition to a critical flow orifice.

Fig. 23-61

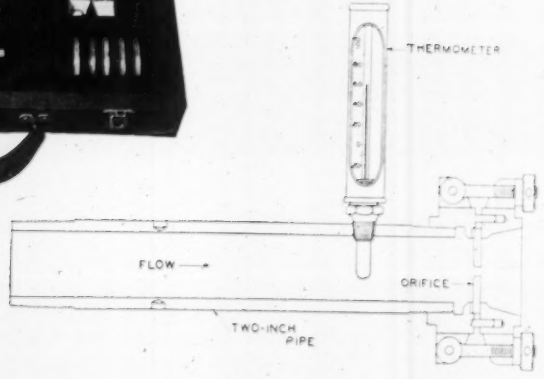

Fig. 23-62

If a critical-flow orifice is used for testing a meter with gas, and it is necessary to place the orifice in a line on the up-stream side of the meter, the orifice should be installed at sufficient distance from the meter so that the temperature of the gas at the meter will not be affected by the rapid cooling due to expansion through the orifice.

Figs. 23-61 and 23-62 show the Pierce Critical Flow Prover (American Meter Co.) and are self-explanatory.

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Multi-Point Temperature Indicator

Westinghouse Elec. & Mfg. Co.

IN many industrial processes, better results can be obtained if the operator can read at one central regulating point the temperatures existing at various remote points. For such applications a new electrical resistance temperature indicator has been brought out. The "Electrotemp" is a simple and inexpensive means of measuring the temperatures, at as many as 8 different locations. Its accuracy is said to be high. The instrument is 8½" high, 3" wide, and 2¾" deep. The Wheatstone Bridge principle of operation is used, with a thermo-sensitive resistance coil located at each of the points where the temperatures are to be measured. Voltage is supplied to the Wheatstone Bridge from 110 volt, 60 cycle a.c. outlet, which obviates the necessity for d.c. or battery supply as is usually present with this class of temperature measuring instruments. Provision is made for easy calibration of the device for any voltage within the limits met on commercial lighting circuits and a "check" position on the dial makes it easy to check the Electrotemp at any time. For cable runs of over 25 ft., 3 leads are run to each resistance coil, and for distances of less than 25 ft., 2 wires are used. The instrument is equipped with a cable or colored leads for connecting to the various thermometric coils. Since low voltage is applied between the instruments and coils, ordinary precautions in wiring, such as standard practice of the underwriters, is not necessary. Ordinary bell wire has sufficient insulation to be satisfactory for connecting between the Electrotemp instrument and its coils.

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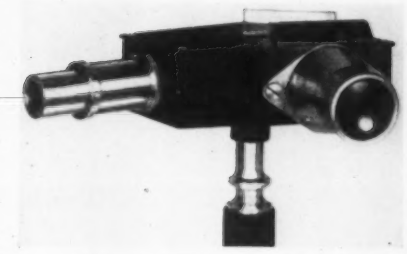
Timing System Approved for Air Races

OFFICIAL approval of the Fédération Aéronautique Internationale has been given to the Western Electric Precision Timer and the timing system under which it operates. This equipment (described in *Instruments*, Dec. 1932) photographs both the finish and the time of finish in fractions of a hundredth of a second. Its advantages for accurate timing were so clearly established that the National Aviation Association of America had urged its international acceptance, now assured.



Miniature Quartz Spectroscope with Wave-length Scale

The Gaertner Scientific Corp.

WEIGHING less than 2 lbs. and no larger than a vest-pocket Kodak, this new instrument is particularly suitable for checking the ultra-violet efficiency of light sources and filters, and the determination of lines and bands in the ultra-violet. The spectrum from 1800 to 8000 A.U. is 22 mm. long and is viewed by a small ocular upon a fluorescent screen just below a wave-length scale illuminated from the light source by a series of reflectors which also serve for aligning the instrument. The eyepiece and fluorescent screen can be swung to permit inserting a photographic film. The instrument is rigidly constructed and neatly finished. A Bakelite handle is furnished for manual use, and a 13 mm. support rod for mounting on a tripod stand.

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Junior Ground-Ohmer

Herman H. Sticht & Co.

A NEW ground resistance meter, marketed under the name "Junior Ground-Ohmer," serves for ground resistance measurements on power, telephone and signal systems, lightning arresters, radio installations,

etc. and can also be used for resistance measurements on wires, etc. It is not recommended for use on live high tension installations, high tension transmission towers or similar installations. (For such measurements the larger Ground-Ohmer is recommended because it gives a warning when excessive high voltages are present.) The Junior Ground-Ohmer uses the same principle as the larger instrument. It has a modified potentiometer system and compares the drop in potential across the ground with a calibrated resistance within the instrument. A microphone is used for balancing purposes. Operation is exceedingly simple. There are no calculations and only one measurement is necessary. The instrument has 3 ranges, namely, 3, 30 and 150 ohms, obtained with a range selector switch.

Photoelectric Relay

Westinghouse Elec. & Mfg. Co.

TURNING electric lights on or off when daylight decreases or increases in intensity to a predetermined value, a newly developed unit, called the Photolux, has various uses from insuring adequate office and factory lighting to lending a maximum of advertising value to illuminated signs and show windows. The indoor models of the Photolux are housed in attractive panel board cabinets for either flush or projection mounting, equipped with locks. In the cabinet is a vacuum phototube, a one-tube amplifier, and the necessary auxiliary apparatus, including a transformer, primary relay, and auxiliary contactors, resistors, potentiometers, and condensers. The adjust-

ment panel contains all the necessary adjustments such as dials, time clock dial, switches, etc. The outdoor model is mounted in a cast aluminum cabinet sealed by gaskets. A padlock may be easily applied by the purchaser. This model is for very sensitive operation and is equipped with copper oxide dry rectifiers which provide power for a very sensitive amplifier circuit. The rectifiers are mounted on the back of the main panel, while the other apparatus such as relays, tubes, transformers, etc., are mounted on the front in the same location as in the indoor units.

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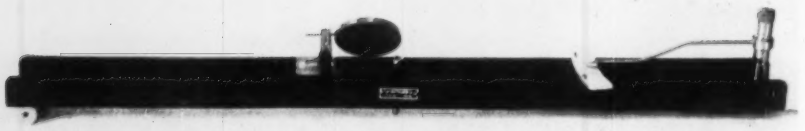
Heavy Duty 4-Pole Relay

Ward Leonard Electric Co.

A NEW relay, identified as Bulletin No. 131, is adaptable to applications where the circuit requires up and down contacts separate from each other. It is said to be particularly suitable for transfer purposes where it is necessary upon operation of the relay that one or more circuits open and one or more separate and independent circuits close. The relay is equipped with 4 poles, 2 of which are normally open and 2 normally closed. Contacts may be easily rearranged for single pole operation. Stiff metal contact fingers, spring shackled and equipped with ample size silver-to-silver contacts to allow a comparatively high ampere rating, make the relay suitable for heavy duty relay or light duty contactor service.



Flatness Tester

The Van Keuren Co.

DESIGNED to give the same precision in measuring machined, ground, scraped or dull lapped surfaces as is obtainable with the optical new flatness measuring instrument consists of a channel supporting a cylindrical line contact at one end, a micrometer with spherical contact at the other end and a very sensitive light wave indicator with a spherical contact in the center. Means are provided for changing the positions of all 3 contacts to accommodate the measurement of different surfaces. Special auxiliary flat contacts are provided for testing machined or scraped surfaces in order to avoid local hollow places. In operation, the micrometer end is lowered until a very slight movement of the interference bands on the indicator shows contact of the center point with the surface being tested. The micrometer reading then shows the amount the surface is convex or concave, after a zero reading has been taken on a master flat. The new tester is particularly suitable for determining the condition of flat ring-shaped laps used on laping machines. Also, it eliminates the need of a third surface in scraping 2 surface plates.

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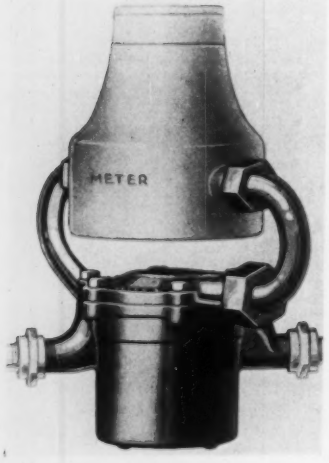
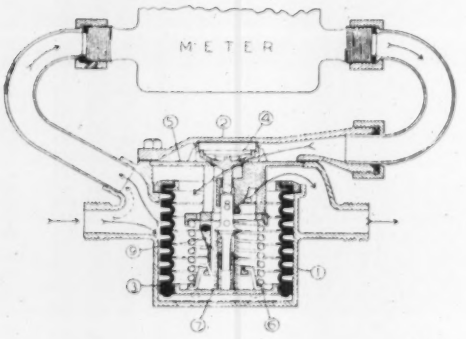
Gulper for Liquid Meters

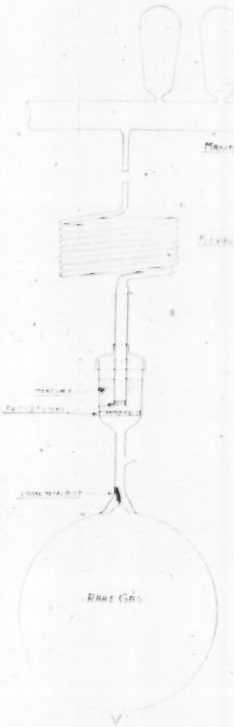
The Ford Meter Box Co.

SMALL flows are not registered by ordinary water meters. Consumers do not pay for billions of gallons wasted through fixture leaks or utilized in gas refrigerators and for other purposes where water is dribbled. In the metering of other liquids, there are corresponding cases of under-registration and non-registration by meters which are not adequately positive. The Gulper is a new device which furnishes a practical solution of this problem. It involves simply the compounding of an ordinary meter with a reservoir so that small flows do not pass through the meter but accumulate first and then pass through the meter at a rate of flow sufficiently large to be registered accurately. Fig. 1 shows how a Gulper (model A) is assembled to an ordinary water meter. The meter sets at an angle of 60° with the Gulper spuds and service line and must be located directly above the Gulper. The combination may be located in any setting formerly occupied by the meter alone, provided there was 5" clearance above the meter register. Fig. 2 is a diagrammatic section. The operation is as follows: On small flows, water entering the inlet of the Gulper cannot pass through the meter because the valve is closed. The small flow to the discharge of the Gulper comes from the inside of the bellows, which is compressed by the inlet pressure on the outside of the bellows. The contraction of the bellows compresses the main spring and the valve spring. When the bellows is compressed to a certain point the tripping mechanism, operating on the toggle principle, permits the valve spring and push-rod to snap open quickly the Gulper valve, permitting water to pass through the meter. The bellows and main spring, being under compression, expand and force a volume of water equal to the bellows displacement up through the meter, through the valve, and into the inside of the bellows. During the gulp water passes through the meter at a rate of almost 2 g.p.m. The expanding of the bellows pulls the valve down to within about 1/16" of its seat from where it drops the remaining distance. A circular slot through the valve just above the point of seating permits the pressure at the point of greatest velocity to be exerted inside the dashpot above the valve. On flows above 1 g.p.m. the velocity past the valve is sufficient to cause this pressure difference to support the valve, holding it in the open position and permitting a steady flow through the meter. Thus the Gulper functions only on flows under 1 g.p.m., cutting out on flows above that rate. Water does not pass through the meter except at rates of 1 g.p.m. or more.



1. Main case
2. Lid
3. Bellows assembly
4. Valve
5. Valve deck plate
6. Main spring
7. Valve spring
8. Push-up rod
9. Tripping mechanism





Valve for Bleeding Gas Under Vacuum

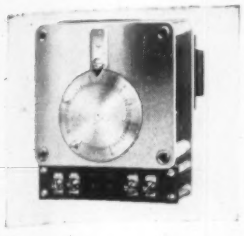
Fish-Schurman Corp.

UTILIZING the properties of metallic mercury and of fritted glass filters, a new valve recently developed for introducing gases at low pressures into highly evacuated systems avoids the uncertainty of plug cocks, etc. Fritted glass filters with very fine pores will not permit the passage of liquid mercury but offer low resistances to gas flow. When two filter faces are brought together the mercury between them is squeezed away, leaving a free passage for gas from one to the other. This principle is employed for the accurately regulated introduction of low-pressure gases into high vacua, as required in the radio and incandescent lamp industries. The apparatus consists of two Jena glass filters facing each other in a bath of mercury. The upper one is sealed into a glass tube connected through a flexible glass spiral to the evacuated system and projects into the mercury. The lower, of larger area, forms the bottom of the mercury bath and its under side is connected to the flask containing the rare gas. A piece of metal enclosed in the connecting tube allows the tip of the gas flask to be broken off by shaking after its contents have been protected by sealing the flask to the assembly. The depth of the mercury required is determined by the pressure of the gas in the flask, if that be greater than atmospheric. To operate, it is merely necessary to press the upper filter disk down onto the lower one and hold it there until the proper amount of gas, as indicated by the pressure, has passed. The illustration shows the apparatus as applied in the high vacuum field, but it is also useful elsewhere for handling gases. By merely increasing the head of the mercury column over the filters to the required point, pressures above that of the atmosphere can be safely handled through the same valving arrangement without leakage or contamination.

Motor-driven Time Delay Relay

Ward Leonard Electric Co.

DESIGNED to produce a definite time interval between two different operations, this new motor-driven time delay relay consists of a small constant speed driving motor, a gear train, a tripping arm and a magnetic operated clutch between the trip arm and gear train. The time interval may be readily adjusted by changing the arc of travel of the trip arm. Various time ranges are provided by standard and special gearing. Standard gearing affords 3 time ranges: 4 to 60 sec., 20 sec. to 5 min., and 2 min. to 25 min. The total maximum input is 5 watts at 110 or 220 volts, 60 cycles, contact capacity 2 amps a. c. or 0.5 amps d.c. The size is approximately 3⅝"x3½"x3" deep.



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The Ignitron Control

Westinghouse Elec. & Mfg. Co.

REVOLUTIONARY in that it employs a new discovery in the field of pure science, a method of controlling mercury-arc devices developed by Dr. Joseph Slepian (discoverer of the "de-ion" principle), assisted by L. R. Ludwig, is more positive and many times faster than methods heretofore in use. The essential feature is a rod of high resistivity, partly immersed in the mercury pool, which when energized displays "very extraordinary properties" with respect to the initiation of arc cathodes on the mercury surface. The mercury pool itself is not an essential element, regular operation having been obtained by Dr. Slepian with a starter rod buried in solidified tin. Arcs are started in less than 5 microseconds, and can be started 60 times per second at any point on the voltage wave. Large currents can be controlled as easily as small ones, the ratio, according to the Westinghouse publicity, being "comparable to controlling by the flip of a small wall switch the quantity of current required by all the homes and industries of a city five times as large as New York!" The control element or "igniter" does not wear out: some rods on life test have each struck >1,400,000,000 arcs without observable deterioration or wasting away.

Applications of the new starter will be obvious to readers familiar with grid controlled gas tubes. In such tubes, until now, an arc cathode was permanently maintained by a separately heated thermionic cathode or a keep-alive arc. The starting of an arc to a main anode was then controlled by a grid. Now the permanent arc cathode and control by the grid may be eliminated, and the starting of the arc to the main anode effected and controlled entirely by the new starter. Thus many of the problems associated with the use of grids, particularly for large currents, are completely eliminated.

Large Motor-Operated Valves

Barber-Colman Co.

AMONG new additions to the above company's electric systems of temperature and humidity control are motor-operated valves in sizes larger than 2". Electrically driven valves suitable for remote automatic or manual control can be supplied, it is said, for many services which hitherto could not be taken care of. There are 3 general types of these valves. The single seat type with renewable composition disk is available in sizes from 2" to 6", will handle pressures from 80 lbs. to 9 lbs. depending on the size, and is made with either positive or reversing motor operators. The semi-balanced double bronze disk type (Fig. 1) is made with vee port disk in 2" to 4" sizes and with standard disk in the 5", 6" and 8" sizes, either positive or reversing for 125 lbs. pressure. The largest one, the full-balanced vee ported piston disk type (Fig. 2) is made in sizes from 5" to 12" with reversing operators only and for pressures up to 125 lbs.

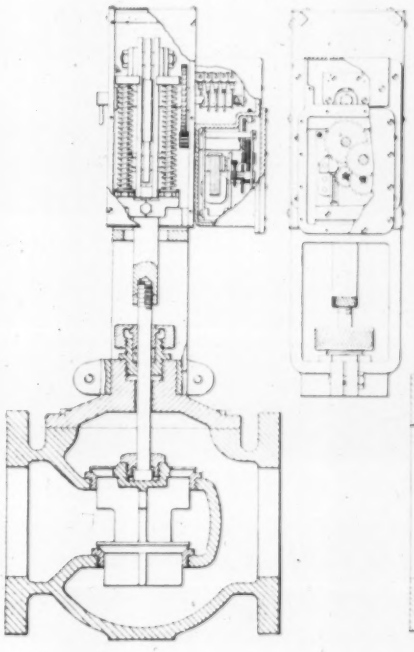

Fig. 1

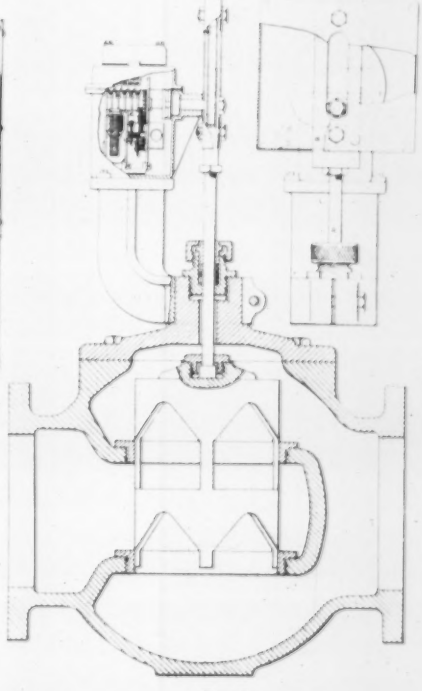

Fig. 2

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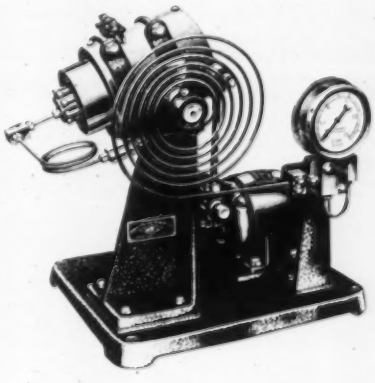
Re-designed Hydrogenation Apparatus

American Instrument Company, Inc.

ROUNDING out a line of American-made high-pressure apparatus styled "Aminco Superpressure Equipment," a new shaking autoclave for hydrogenation at high pressures and temperatures has a rocking mechanism which has been simplified and lightened, without loss of strength or sturdiness. The instrument is designed for operation at pressures up to 15,000 lbs./in.² and temperatures up to 752°F.



Free Air Strut Thermometer

Consolidated Ashcroft Hancock Co.

MOUNTED on a strut in the free air flow and away from the propeller slip-stream, this new instrument indicates the actual temperature of the air through which the plane is passing because the air circulates around the thermal element. Zero C. at top center, and radium painted pointer, make night readings as easy as in daylight. The dial diameter is 2¾".

Refractory Protected Mercury Switch

Westinghouse Lamp Co.

MADE with nominal ratings from 3 amp. to 50 amp., a new line of single pole, single throw switches which may be operated in either a.c. or d.c. circuits is characterized by refractory protection to confine the arc. Contact is made by an impact between two pools of mercury within a refractory chamber encased in heavy glass walls. Instead of flowing, the mercury from one pool drops suddenly to meet the other. Inert gas keeps the mercury pure and free-flowing, and dissipates the heat of the arc. The 6 switches in the line have flexible leads 6" to 8" long, and are available with special mounting clips to facilitate installation. General characteristics:

	Angle of Operation			
Rating	*Min. Range*	*Max. Range*	*Diameter*	*Overall Length*
3 Amp.	3°	8°	0.410" to 0.480"	$2\frac{5}{16}$"
10 Amp.	15°	20°	0.610" to 0.650"	2"
10 Amp.	6°	15°	0.610" to 0.650"	$3\frac{1}{4}$"
20 Amp.	6°	15°	0.950" (Max.)	$3\frac{13}{16}$"
30 Amp.	6°	15°	0.950" to 1.070"	$4\frac{13}{16}$"
50 Amp.	—	30°	1.080" to 1.270"	$4\frac{13}{16}$"

The 50 and the 3 amp. switches, the largest and smallest in this new line, are shown in the illustration.

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Open Contact, Low Voltage Humidity Controller

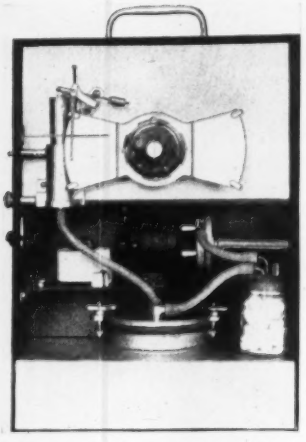
Lewis Air Conditioners, Inc.

A NEW model of the Humitrol is announced, designed for use with transformer in low-voltage air conditioning control systems up to 25 volts. Direct application can be made to equipment drawing up to 25 watts. By the use of transformer relay combinations heavier equipment can be commanded. The new model has a smaller differential than that of the mercury switch models, 1% now being possible. Ribbon actuating element, walnut Bakelite case and other features of the mercury switch models are retained.

Improved Combustion Recorders

Defender Automatic Regulator Co.

EASIER zeroing, by means of a simple thumbscrew, is one of the improvements found in the new models of the Defender portable 1-, 2- and 3-pen CO_2 recorders. The water level in the tank in which the bell float works is maintained more closely. The small universal motor and rheostat are now located on a detachable shelf. The small



portable Orsat for periodical calibrating of the recorder is placed inside the case through a door (not visible in our illustration); and the rubber tubing, gas filters and other fittings are also packed in this same compartment, allowing the entire outfit to be carried in one hand and preventing forgetting parts when traveling.

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Temperature and Pressure Recorder-controllers

Consolidated Ashcroft Hancock Co.

AT the will of the operator, either "on-and-off" action or "throttling" regulation can be obtained with this new air-operated recorder-controller, styled the "Controlograph." Changing from one mode to the other is effected by merely shifting a little lever. Although a single thermal tube system or pressure-spring drives the recording

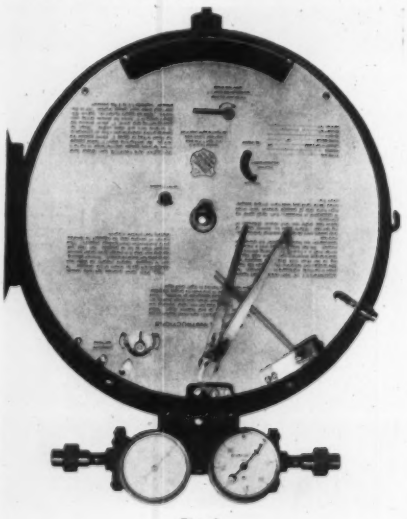

Fig. 1

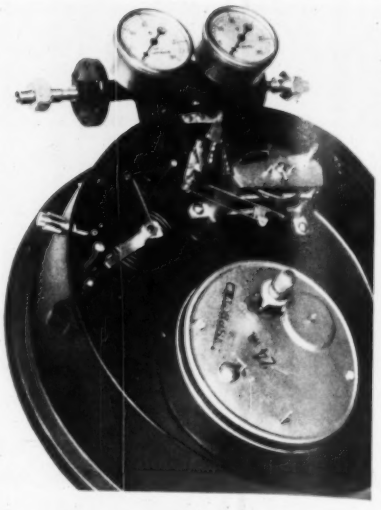

Fig. 2

pen and also actuates the pilot air valve, the construction is such, it is said, that the recording element may pass the control point without affecting the accuracy of the temperature or pressure record which, therefore, truly serves as a check on the performance of the automatic control elements. A novel and useful feature is that complete instructions are lithographed on the chart plate, as shown in Fig. 1.

Fig. 2 shows a mercury-system temperature Controlograph with chart plate, pen-arm and control index removed, making apparent its simple design and neat construction. Spring-wound or electric 12-hr. or 24-hr. or 7-day clocks are standard; other rotation periods are also available. The American Time Punch, for perforating edge of chart, is standard on all models. The 10" charts have a 3" effective scale length. Temperature range limits are —40°F. and 1000°F.; mercury or vapor-pressure systems being available. For pressures, range limits are 15 and 1000 lbs./in.^{2}. Charts are available in ranges suited to numerous industrial process applications such as canning retorts, annealing ovens, milk pasteurizers, etc.

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Automatic Weight Recorder

Streeter-Amet Co.

READILY attachable to any scale, whether on pan, basket, hopper or platform, a new model fully automatic weight recorder designated as Type LV combines a full-capacity reading dial and a weight-printing device. The action of the indicating dial has been perfected and it is said to give the correct weight "before ordinary dials stop wiggling." The recorder prints on a 1" wide tape supplied in rolls on which may be printed as many as 7000 weights. The live portion of the tape passes over a conveniently slanted "desk" to allow writing notes alongside of the printed figures. Type LV is fully enclosed to keep dust from knife edges and working parts. The case may be locked to prevent tampering. This new recorder may also be furnished with tape entirely enclosed and without a dial—for use in plants where formulas or processes are to be kept secret.

Triple Service Aircraft Engine Unit

Consolidated Ashcroft Hancock Co.

COMBINING in one case 3 essential measuring elements for aircraft engine operation, this new instrument indicates oil temperature, oil pressure and fuel pressure. The 3 scales comply with aircraft standards; the diameter of the dial is 2¾". Pointers, figures and major scale divisions are radium painted. Interrupted radium stripes along the scales delimit the safe operating temperature and pressures. On multi-motored planes this "American Triple Service Engine Unit" saves considerable space and some weight.

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New Line of Indicating Pyrometers

Mishawaka Industrial Instrument Mfg. Laboratory

NUMEROUS combinations of several case models with several thermoelements in various protecting tubes make up this new line of thermoelectric pyrometers. All styles of instruments are indicating. They comprise models for panel mounting, wall mounting, multiple-point and portable. Automatic cold-junction compensation is standard throughout the Mishawaka line. Cases are of cast aluminum attractively finished and enameled, height 5½", width 4⅝" and depth 2½". Instrument weighs 3 lbs. Among the models of particular industrial interest are some which consist of instrument cases assembled to protected couples, making units said to be as convenient as vertical or angle stem industrial thermometers and more accurate. Fourteen standard ranges are listed in the Laboratory's initial announcement.

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Ring Type Rheostat

Ward Leonard Electric Co.

THIS new ring type rheostat is for heavy duty but it provides a fine continuous adjustment. The resistance wire is wound toroidally around a base of refractory material and coated with Vitrohm (vitreous enamel) to prevent its shifting with adjustment of the contact shoe. The "dead" shaft, insulated from the contact lever, makes the rheostat adaptable for mounting back of a steel panel without the use of insulating bushings or washers. The rheostat can be furnished in values of resistance from 1 to 10,000 ohms. It will dissipate in free air 100 watts continuously with a temperature rise not exceeding 250° C., which is within the limits specified by Underwriters' Laboratories.

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Combination Pressure Recorder-controller and Flowmeter

The Foxboro Co.

THIS is an instrument for recording and controlling pressure, and recording flow. The pressure controlling mechanism is of the "Stabilog" type, which permits full-floating valve action. The flow meter construction is identical with the makers' latest developments in flow instruments. A number of these recorder-controllers have found application on gas pressure regulation where flow measurement is essential, such as in back pressure regulation with metering of tail gas from oil refining processes; on steam lines and fuel gas lines where pressure reduction is important and metering essential; on water lines, brine lines and similar services. The new Combination Pressure Stabilog and Recording Flow Meter is available in either flush type or surface mounted case, with weatherproof door construction. If required, the case may be built gas-tight and vented to operate on natural gas instead of compressed air.

Aircraft Dial Thermometers and Pressure Gages

Consolidated Ashcroft Hancock Co.

INDICATION of cooling water temperature or oil temperature is the purpose of the new aircraft instrument herewith illustrated. A companion instrument has been brought out for indicating fuel pressure. Flush mounted Bakelite cases and 1¾" dials comply with the latest aircraft standards. Plain or radium-painted pointers, figures and major scale divisions, also Fahrenheit or Centigrade thermometer scales, are available.

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Compact Switchboard Instruments

Westinghouse Elec. & Mfg. Co.

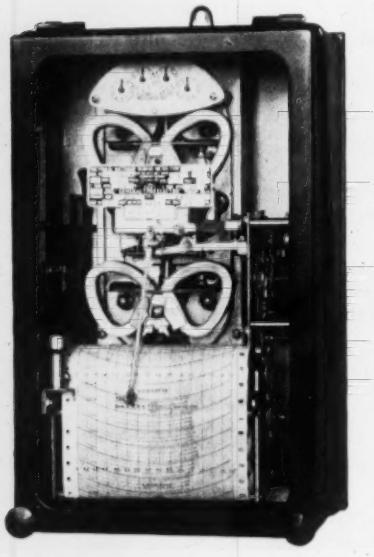
COMPACTNESS, and good appearance are obvious characteristics of a new line of rectangular flush mounted instruments supplied with illumination. A novel method of attaching the front cover eliminates all screws from the front plate. The occupied panel area is 4½" of width by 4¼" in height

but mounting details are worked out to permit grouping instruments on 4" vertical center lines, so that 1 sq. ft. holds 9 instruments. The scale length is 3½". Movements designed for regular large switchboard instruments are used. The instruments are available in Volts, Amperes, Watts, Power Factor, Frequency, Reactive Volt Amperes, and Radio Frequency Amperes. Permanent magnet moving coil mechanisms are available for Volts, Amperes, Rectox Voltmeters, and Milliammeters; also, Temperature Indicators.

Watthour Demand Meters

General Electric Co.

COMBINING in one device a watthour meter and a recording demand meter, the new Type DG-1, of the "block-interval" type, has a demand mechanism recording on a strip-chart the demand over a definite time interval. A line is made on the chart for each period, with ⅛" interval between these lines for all ratings. A hook at the end of each line indicates the exact value of the demand. The chart travels continuously, so that line slope is a function of the load. Among the characteristics are high torque and complete temperature



compensation for all power-factors. The combination of high torque and efficient demand mechanism results in a minimum effect on the watthour meter accuracy, even under light load conditions. The watthour register is separate from the demand mechanism, allowing either one to be changed independently to take care of changes in ratings of instrument transformers. The watthour meter disk shaft has 2 worms cut on it: the top one drives the standard watthour register; the lower one, through a suitable gear train and clutch, drives the recording pen mechanism. This clutch is "slipped" when the pen is reset at the end of the time interval. A Telechron synchronous motor drives and rerolls the chart, winds the pen resetting spring, and actuates the resetting mechanism. At the end of each time interval a cam unit, attached to the normally stationary end of the resetting spring, is released and allowed to make a complete revolution. This motion is transmitted to 2 cams, which likewise make one complete revolution. In so doing, through suitable lever arrangements, the pen first makes a small hook at the end of the line and then flies back to zero. The terminal arrangement is universal, for either front or back connections. Front connections are made to bottom terminals.

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A new totalizing machine, being built at the Arlington Park race track in Chicago, issues tickets from 150 windows, totals the amount of money received, and registers all odds. 2 carloads of copper wire are being used in its construction.

A.S.T.M. Exhibit at Chicago, June 26-30

SPECIAL testing equipment developed by research laboratories and A.S.T.M. committees will stand out among the displays in the Second Exhibit of Testing Apparatus and Equipment, which the American Society for Testing Materials is holding at The Stevens, Chicago, June 26-30.

In the manufacturers' booths will be found equipment for tests and studies of metals, cement and concrete, petroleum products and many other engineering materials, as well as laboratory apparatus and other scientific and industrial instruments. Hardness testing equipment, laboratory glassware of all types, universal testing machines, balances, thermoregulators, fatigue testers, etc., will be shown.

A.S.T.M. committees which are planning to participate include A-10 on Iron-Chromium-Nickel and Related Alloys; C-1 on Cement; C-7 on Lime; and D-9 on Electrical Insulating Materials. Each of these committees has developed new methods and new apparatus since the 1931 exhibit, and many of these specialized instruments will be on display.

University and other research laboratories will show ingenious equipment which they have developed for making special tests and determinations. There will be a machine to test the soundness of welded pipe joints; apparatus for testing of foundry cores; an instrument which magnifies 2000 times the contour of machined surfaces; sound testing equipment including a voice recorder for sound intensities of human speech, wind meters, lathe dynamometers and other special devices.

Included in the non-commercial exhibitors are the University of Michigan, Ohio State University, Bureau of Standards of Los Angeles and other research laboratories.

The Exhibit opens at The Stevens, Monday noon, June 26, extending through Friday, June 30.

A list of the manufacturers exhibiting commercially available instruments and apparatus follows:

Baldwin-Southwark Corp.—Southwark-Emery Universal testing machine, mechanical weighing unit, and Stress-Strain Recorder; fatigue and damping tester; strain gages; extensometers; engine indicators.

Central Scientific Co. New scientific instruments and apparatus pertaining to divisions covered by Society standards. New Cenco constant temperature ovens; water baths; thermoregulators; electric heaters; high vacuum pumps, etc.

Christian Becker, Inc. Balances:—analytical Chainomatic, micro, surface tension and laboratory.

Kimble Glass Co. Complete line of chemical glassware featuring apparatus used for A.S.T.M. methods.

Precision Scientific Co. A.S.T.M. laboratory testing apparatus.

E. H. Sargent & Co. Scientific and laboratory apparatus.

C. J. Tagliabue Mfg. Co. Oil testing instruments; electrical pyrometers; instruments for determining moisture content of materials; temperature, pressure, flow and level recorders.

Wilson Mechanical Instrument Co., Inc. Rockwell hardness testers; Rockwell superficial hardness testers.

Instruments' Book Shelf

(Continued from page 124)

receives a surprisingly detailed analysis.

So great has been the number of papers on the experimental determination of the effective wave-length of a colored glass (not to mention chapters in various books) that the reviewer expected neither a lengthy treatment nor a new approach. Prof. Ribaud devotes 10 pages to this subject, summarizes the past work and contributes a distinctly new approach: first he discusses the Hyde, Cady and Forsythe method; next he points out the limitations of the simplified method of de Groot; then he describes not only the Rothschild Laboratory's "direct method" which he had first announced in 1928 but two new variations of this method. Furthermore, he discusses the obtainable precision of this method, gives test results and reports how his associate J. Mendousse has "perfected" his method. The reason the reviewer dwells so long on these 10 pages is because he believes that Ribaud has given us "one more decimal place." Not that it was heretofore impossible to measure effective wave-length to a few Angstroms, but it simply wasn't done in general practice. For example: sellers and buyers of optical pyrometers advertise and inquire in terms of microns. Get them talking Angstroms and what will happen? The same thing that happened when machinists discarded plain calipers for micrometers reading to 0.0001 in. The pyrometer user, knowing that his instrument has an effective wave-length of, say, 6523 ± 3 A.u., will demand scales and correction tables and graphs based on that value and not on "0.65μ" which may mean any value between 6450 A.u. and 6550 A.u. The spread of this one refinement of technique, even if unaccompanied by others as it must be, would better the precision of industrial pyrometry, the reviewer believes, for what we usually call a "small" uncertainty in the value of λ may mean a considerable uncertainty in temperature measurement: an error of 50 A.u. in λ when the source is a black body means, *e.g.*, an error of 75° C. in extrapolating from the gold to the platinum point.

Chap. XI is mainly devoted to spectro-pyrometers but expounds the principle of the adaptation of spectrophotometers to the comparison of two luminous sources.

Chap. XII is on the Effective Wave-length of a Pseudo-monochromatic System. That a whole chapter of 37 pages should have been devoted to the "color" of colored and absorbing glasses seems astonishing, until one reads at its beginning the flat statement that "divers old definitions [of effective wave-length] . . . must be considered incorrect." This chapter really is "required reading" for all pyrometricians on this side of the Atlantic. The equations derived by Foote in 1915 and Hoffmann in 1923 were thought to leave little for subsequent workers, but Ribaud shows that λ_L is not only a function of the temperature of the black body source sighted on but of other conditions as well. He starts from the beginning and branches off into cases heretofore unexplored. He reports direct measurements under various conditions undertaken at the Rothschild Foundation Laboratory with a special apparatus which he and his assistants devised. In short, he makes a distinct contribution to the art in this chapter and in the next two (XIII and XIV) wherein he discusses the choice of colored and of "neutral" glasses used in pyrometry. He reports numerous measurements which he made personally and insists that it would be desirable to have trustworthy neutral glasses ("pratiquement neutres" = neutral in practice).

Two chapters are then interpolated on the realization of black bodies and on black body laboratory set-ups for obtaining the melting points of various metals in the process of calibrating pyrometers. The treatment is adequate, well illustrated, and of practical usefulness to the laboratory technician. He approves the simplified black body described by Roberts in the *Journal of the Optical Society of America*, 1925, page 729.

as well as the more elaborate ones; and describes his own tubular black body whereby he perfected the method of Lres. This part includes notes on the commercial purity of various metals and on their melting and freezing curves.

The next chapters, describing and discussing various types of optical pyrometers, are of interest chiefly by reason of their authorship. Ribaud seems to think little of commercially available polarization instruments but goes into details on filament types and gives excellent practical instructions for their calibration and use. His treatment if far from comprehensive as regards the instruments on the market, but he describes the precision disappearing filament pyrometers of the Bureau of Standards and of his laboratory, and he devotes the greatest number of pages to his own combination wedge-and-filament method and concludes by describing the new industrial pyrometer which employs this method. This is a French made instrument, the others are not. (It may be, though, that this instrument is far better than the others and deserves the place of honor in any treatise on optical pyrometers. The reviewer himself regrets not knowing about this instrument when he issued his handbook and hereby promises to include it in the next edition.) We do not find fault with the omission of many well-known *makes* but we cannot understand the omission of *types* which are each represented by one or several makes. Ribaud gives the impression that he never heard of certain *principles* or *methods* other than those employed in the instruments he describes. This is unlikely, because in addition to being Director of the Rothschild Foundation's Pyrometric Laboratory he is a professor at the University of Strassbourg, a metallurgist and the author of works on induction and resistance furnaces. Why then does he not at least mention the "extinction" and "two-color" types of optical pyrometers? Why does he not even include a brief *list* of the principles and methods employed in practical optical pyrometry?

The final four chapters in the book deal with flat filament standard lamps, with fixed points higher than the gold point, with total radiation pyrometers and finally with the characteristic radiations from various luminous sources. The 42-page chapter on total radiation pyrometers constitutes an excellent little treatise on this subject. Ribaud declares that the radiation pyrometer is "a grossly imperfect instrument, utterly discarded in pyrometry laboratories, and the sole merit of which is to permit obtaining continuous records in industrial work." He discusses cumulative errors and complications which inevitably result in the e.m.f. departing widely from the fourth-power law.

Like more other French scientists in their writings, Prof. Ribaud does not hesitate to state his personal opinions. To the reader's delight, for example, he seasons the customary citations of references with outspoken comments on their relative values. In this connection it will interest readers of *Instruments* to know that he cites Bureau of Standards physicists much more frequently than all others. Forsythe is cited 65 times and Burgess 40 times; Hyde gets 26 mentions, Foote 24, Coblentz and Waidner 20 each, Cady 18, Fairchild 12, Day and Sosman 9 and Peters 8. Among other Americans Mendenhall gets 18 mentions, Thwing 7, Langmuir 6 and Leeds 3 .

Also in this connection it is worthy of mention that the paper on *Optical Pyrometry* by Waidner and Burgess (Bu. of S. Scientific Paper No. 11, 1905) is not mentioned in the bibliography appendix. Worthy of mention, because this Waidner-Burgess paper, although it only ran to 66 pages in the Bureau of Standards *Bulletin* and although it was only a thin paper-bound pamphlet when issued separately shortly afterward, was really the first "book" on optical pyrometry and remained the only one for many years.

As in most first editions of lengthy scientific treatises, there are minor imperfections throughout. Typographic errors abound, but the publishers no doubt circulated the body of the book (pages 1 to 486) before printing the initial signature (pages i to xvi) for we see "Errata" printed on page xvi. Unfortunately these corrigenda are incomplete, and to make matters worse an error crept into that very list!

But in spite of minor shortcomings this is a monumental—indeed a great scientific book.—M. F. Behar **(2.06)-B-**

High-Frequency Measurements. By August Hund. McGraw-Hill Book Company, New York, 1933. Cloth, 491 pages, 5½ x 9 inches. Price $5.00.

To one who has considered high-frequency measurement as a branch of the general art of electrical metering, and who has thought that a book on such a subject must be very brief and highly specialized, the advent of this volume comes as a distinct surprise; and until one scans its half-thousand pages, one can hardly realize what a mass of information in the upper frequency ranges has been collected, almost entirely in the past two decades. "This treatise is not a translation of the author's book *Hochfrequenzmesstechnik* but may be regarded as an up-to-date work on high-frequency phenomena applied to measurements." It deals of necessity with methods covering a wide frequency range. "What may be geometrically a coil and behave as an inductance in effect for the lower frequency range, may act in effect as a capacitance in the upper frequency band." In confirmation of this, the book opens with expositions and discussions of many fundamental formulas, stressing those features wherein magnitudes, negligible at commercial frequencies, may at high frequencies become the controlling factors in the circuits. No detail is spared to make clear the basic principles involved, and the author does not hesitate to resort to fundamental physics, when needful to give a good perspective of high frequency phenomena or of the properties of electronic circuits.

Where necessary in order to show the importance of certain measurements, there are provided theoretical explanations of the phenomena to be measured. In fact theories are discussed to such a degree that the volume, aside from its treatment of the subject of measurement, might be looked upon as a fairly comprehensive work on the physics of high-frequency phenomena. The subject matter is occasionally clarified by suitable analogues, including a striking presentation of data comparing the magnitude of the electron with our common mechanical and electrical conceptions.

In the earlier part of the book is found a full discussion of all types of high frequency sources and of transformers, both iron and air cored; while oscillographs of several classes, and methods for determining wave shapes and form factors receive exhaustive attention. As a "fundamental" of the subject is treated the importance and technique of shielding, as applied not only to the actual measuring apparatus but to the generators and accessory circuits. In a chapter devoted to current detectors and measuring devices for small tube and ionization currents, are included special galvanometers for high-frequency work and the application of bridge networks, resistance and reactance potentiometers. For the measurement of high-frequency voltages, there are fully described the principles of 8 different classes of apparatus, no less than 24 pages being devoted to the several types of vacuum-tube voltmeters. In the chapter on frequency determination a careful discrimination is drawn among radio, audio and commercial frequencies, showing the methods best suited to each range. Capacitance and inductance measurements, mostly by bridge systems, are exhaustively treated.

The effective resistance of a conductor on high frequency, as related to its true ohmic (or d.c. resistance, is carefully differentiated from impedance effects due to the geometric configuration of the circuit by the following definition: "In all cases, the high-frequency resistance is that quantity which, when multiplied by the square of the effective value of the high-frequency current, gives the energy dissipated in the conductor." Full information is provided as to means for separating the several components of the resistance; and in connection with this the design of "litz" wire is treated in considerable detail.

All practicable methods for determination of power in high frequency circuits are given, stressing the importance of the cathode ray tube, not only in power measurement but in its application to the investigation of hysteresis and magnetic characteristics in general. While in the study of vacuum tubes much attention is given to those factors which affect modulation and audibility, the author's treatment of the subject differs from others in that consideration is also given to the characteristics which render electronic tubes useful in other fields than that of sound. This feature appeals to the research engineer.

The parts of the work which deal with quartz crystals and the piezo-electric effects upon which their performance is based appear to fall short of others in the lack of sufficient theory to enable one not versed in their operating principles to grasp just what takes place in the quartz oscillator. It would seem that if more attention had been given, either in the text or in the bibliography, to the fundamental properties of piezo-electric crystals, the subject would have been materially clarified and this branch brought into keeping with other sections.

In those cases where the procedures of high-frequency measurement apply with particular effectiveness in commercial ranges, these applications are made very plain; and the volume closes with an important chapter on miscellaneous applications of the principles involved, wherein may be found many valuable hints and inspirations for further research. Appended to this chapter are found 20 pages of tabulated data on high frequency circuits, which, taken with other tables, mostly too new to be found in any other text or handbook, and scattered throughout the work, supply a vast fund of time-saving material for the benefit of those engaged in high-frequency measurement. The work is profusely and neatly illustrated with consistently depicted diagrams and graphs, there being in all 373 apparently original line drawings.

It is seldom that there appears a technical book in which we find so much related information, that has not heretofore been systematically grouped. As indicated by the ample bibliographies, the author has gone far afield for his data, and has combined the material, along with his own original work, in a most admirable manner. The book serves as an excellent example of that ever-welcome type of treatise which forms a bridge between pure physics and practical engineering.

—Perry A. Borden (5.4)-B-

American Standard Practice for Inch-Millimeter Conversion for Industrial Use. American Standards Association, New York, 1933. 8 pages, 7¾x10½ inches. Price 20 cents.

This is the American Standard approved March 13, 1933, by representatives of American industry and engineering societies. The conversion factor is now 1 inch = 25.4 mm exactly. Inasmuch as the difference between this and that derived from the official U. S. relation (1 inch = 25.40005 mm) amounts to 2 parts in a million, the adoption of this standard will not affect interchangeability or correct fitting of parts. It will not even be necessary in industrial practice to marks gages to indicate that they are on the new basis. Only the manufacturers of gage blocks and other standards will find it advisable to revise their literature when changing over. On the whole, the issuance of this Standard is an excellent step. The pamphlet contains conversion tables and other useful data.—M. F. Behar (1)-B-

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Nelson E. Chance, formerly district manager of the Houston office of The Brown Instrument Company, has been appointed Assistant Sales Manager, with headquarters at Philadelphia. Mr. Chance has been with the Company over ten years and for seven years was manager of the district comprising Texas, Louisiana and Southern Arkansas.

INSTRUMENTS ABSTRACTS

Abstracts on instruments and devices for measurement, inspection and control.

Photo-electric Measurements, Devices and Applications (5.3)

Photoelectric Cells and Their Applications. (Photoelektrische Zellen und ihre Anwendungsmoglichkeiten.) W. Kluge. *Feinmechanik und Prazision*, Vol. 40, April 1, 1932, pages 61-65.

The fundamental laws and theory are given. Materials for the light-sensitive cathode are described. Each metal possesses a certain range of wave-lengths of particularly high, resonant sensitivity; the electro-negative metals in the invisible ultraviolet spectrum beginning at about 300 mu. The commercial manufacture of photocells is described and characteristic curves of different cells are reproduced. Ha (5.3)

An Application of the Photo-Electric Cell to a Comparison of the Efficiencies of Photographic Shutters. John S. Anderson. *Transactions of the Optical Society*, Vol. 32, No. 5, 1930-1931, pages 197-204.

The efficiency of a photographic shutter is defined as the ratio of the total amount of light which passes through the shutter to the amount which would have been transmitted if the light had not been obscured by any part of the shutter during the whole period of exposure. A method of measuring the amounts of light passed by the shutter by photo-electric means is described and its theoretical basis explained. Ha (5.3)

The Present Status of the Electric Eye. *Product Engineering*, Vol. 3, May 1932, pages 194-196.

The various light-sensitive devices are classified: (1) photo-electric tubes, (2) selenium cells, (3) photovoltaic cells or "light batteries," (4) dry oxide plates. The different types are briefly discussed and industrial applications described. Ha (5.3)

Photoelectric Effect and Electron Reflection on Hydrogenated Surfaces of Potassium. (Ueber lichtelektrische Wirkung und Elektronenbeugung an hydrierten Kaliumoberflächen.) W. Kluge & E. Rupp. *Physikalische Zeitschrift*, Vol. 32, Feb. 15, 1931, pages 163-172.

A testing method is described for carrying out photo-electric measurements and investigations of interferences by means of reflected electrons on the same surface of a metallic sample. EF (5.3)

Light Sources for Movie-Sound Recording. (Lichtquellen fuer Tonfilmaufnahmen.) H. Ewest. *Zeitschrift fuer technische Physik*, Vol. 12, Dec. 1931, pages 645-647.

The essential data on the lamps employed at the present are given and the future trend is appraised with regard to a novel experimental point discharge lamp. Paper at the 7th Deutscher Physiker und Mathematiker-tag, Elster, Sept. 13-18, 1931. EF (5.3)

The Scanning of Pictures in Television. (Die Bildabtastung beim Fernsehen.) F. W. Winkel. *Zeitschrift fuer Fernmeldetechnik, Werk- und Geraetebau*, Vol. XI, June 28, 1930, pages 92-95.

The history of the "mosaic method" which employs several Se-cells (de Paiva, Senlecq, Schmierer, Bell Telephone Co.) is traced and the new methods which use only 1 cell are discussed in detail with particular emphasis on the different methods of scanning the entire surface of the pictures. The methods of Jenkins and von Mihály are stressed and the utilization of the cathode ray oscillograph (Rosing, Dieckmann, Zworykin) is considered in conclusion. EF (5.3)

Selenium Cells for Photoelectric Measurements (Selenzellen für lichtelektrische Messungen). Rudolf Sewig. *Archiv für Technisches Messen*, Vol. 1, Feb. 23, 1932, section F 393-1, page T 12.

A brief historical sketch and description of its physical and chemical properties is given and then the change of its electric conductivity by light treated in detail. The various forms of cells, their response, the current produced and the influence of color are discussed. Disadvantage of selenium is its lag. Ha (5.3)

Photo-Electric Lighting Control Relay. *Power*, Vol. 74, Nov. 10, 1931, page 688; Vol. 75, Feb. 23, 1932, page 295.

Descriptive. AHE (5.3)

Electron Tubes New Tools for Power Engineers. *Power*, Vol. 75, March 22, 1932, pages 430-433.

The operation of paotoelectric and 3-element vacuum tubes is explained, with diagrams. Applications—rectifying alternating current, measuring smoke density, water turbidity, etc., are described. AHE (5.3)

A.C. Motors—Automatic Kick-Back-Photo Cell Signal Are Features of Car Dumping at Waukegan. *Power*, Vol. 75, March 22, 1932, pages 440-441.

A photocell watches empty cars and causes operation of a retarding mechanism. AHE (5.3)

A Photoelectric Method for Testing Camera Shutters. H. J. Reich & Gordon S. Marvin. *Review of Scientific Instruments*, Vol. 2, Dec. 1931, pages 814-817.

The use of a photocell in conjunction with an electromagnetic oscillograph is described to determine the amount of light passing through the shutter, the time of exposure, the speed with which the shutter opens and closes. The time is determined by the simultaneous recording on the oscillogram of an alternating current of known frequency. Ha (5.3)

Phototube Relay. Electrotec Engineering Corp. *Instruments*, Vol. 5, Feb. 1932, pages 53-54.

This phototube relay can be adjusted externally to operate on a change of one tenth foot candle in illumination, or for impulse-operating from a light source. HO (5.3)

Color Matcher. Westinghouse Elec. & Mfg. Co. *Instruments*, Vol. 5, Feb. 1932, page 54.

Nearing completion of development is this self-contained portable, photo-electric color matcher which operates from regular 110 volt power supply. HO (5.3)

Rapid Counting Relay. (Schmellzähl relay.) *A E G-Mitteilungen*, Feb. 1932, page 62.

The relay responds to up to 20 light impulses per second. It can work mechanically or with a current amplifying arrangement. Ha (5.3)

Photoelectric Rapid Counters. (Lichtelektrische Schnellzählereinrichtung.) E. Bornitz. *A E G-Mitteilungen*, Feb. 1932, pages 60-61.

Describes an arrangement which can count up to 1200 in a minute for quantity articles which pass through the path of a light-ray. Ha (5.3)

Photocell Controlled Elevator Doors. C. E. Ellis. *Electronics*, Vol. 4, Feb. 1932, pages 54-55.

Close in front of the elevator door and parallel to it are two beams of light which permit the door to close only when unobstructed by a passenger. Ha (5.3)

Physical Properties and Design of Photo Cells for Sound Film Purposes. (Physikalische Eigenschaften und technische Gestellung von Photozellen fuer Tonfilmzwecke.) W. Kluge. *Zeitschrift fuer technische Physik*, Vol. 12, Dec. 1931, pages 649-661.

Paper presented before the 7. Deutscher Physiker und Mathematikertag at Bad Elster, Sept. 13-18, 1931. Photocells, their manufacture, the nature and structure of light electric cathodes; measurements on spectral sensitivity, linearity between photo currents and exposure, etc. Instructions regarding the arrangement of photo-cells in the installation set. Conditions which must be observed with respect to the photo cell during the sound film photography. EF (5.3)

Electric Measurements, Tubes, Devices and Their Applications (5.4)

An Electronic Tool of Many Uses for Measurement and Control. H. Olken. *Instruments*, Vol. 5, May 1932, pages 113-114.

Considers the electron tube oscillator a "jack-of-all-trades" to serve the needs of industry in measurement and control. Discusses oscillator types and modes of operation and presents several applications of the outstanding features of the oscillator, namely: extreme sensitivity, permitting measurements to millionths of an inch; non-contacting response, providing relay action without mechanical operation of the relay, and measurement without contacting the object measured, as for example gaging sheet rubber by passing it between the two fixed plates of the oscillator's tuned circuit condenser. Applications to time, frequency, measurement are also presented. (5.4)

Electron-Tube Applications to Power Generation and Control. *Power*, Vol. 75, April 5, 1932, pages 514-518.

Uses described include motor speed control, power transmission, rectification for electrical precipitation, voltage regulators, synchronizers, telemetering, strobaglow, and automatic leveling. AHE (5.4)

A Method of Obtaining a Linear Time Axis for a Cathode Ray Oscillograph. A. L. Samuel. *The Review of Scientific Instruments*, Vol. 2, 1931, pages 532-540.

See *Instruments*, Vol. 5, April, 1932, page 118. (5.4)

New Vacuum Tube. General Electric Co. *Instruments*, Vol. 5, April 1932, page 109.

Describes new "low noise" type PJ-11 Pliotron, exhausted to a billionth of an atmosphere, reducing the noise level between 100 and 1000-fold. MPB (5.4)

A Cathode-Ray Frequency Multiplier. Noel C. Jamison. *Physics*, Vol. 2, Apr. 1932, pages 217-224.

Vacuum tube has a filament and slit arrangement for the production of a sheet of electrons, one pair of deflecting plates, and a receiving plate composed of a series of rectangular conductors—adjacent conductors insulated from one another and alternate conductors in electrical contact. Alternating potential difference applied to deflecting plate causes electron beam to move across receiving plate, current flowing first to one set of conductors and then to the other. During one complete cycle of the deflecting plate field, the currents from the two sets of conductors pulsate with frequencies which are multiples of the frequency applied to the deflecting plates. WAT (5.4)

"Cheater Circuits" for Synthetic Testing of Mercury-vapor Power Tubes. J. L. Zehner. *Electronics*, Vol. 5, July 1932, page 224.

Illustrated description of testing apparatus for large power tubes and mercury-vapor rectifiers, developed by General Electric Co., employing synthetic testing ("cheater") circuit, to minimize power consumption and at same time reduce cost of installed apparatus. MPB (5.4)

The Rapid Record Oscillograph in Sound Picture Studies. A. M. Curtis, T. E. Shea, & C. H. Rumpel. *Bell Telephone System Technical Publications*, Monograph B-644, 1932, 15 pages.

Describes a special oscillograph which was designed for making rapid records in sound picture studies. The oscillograph is briefly described, and illustrations are presented of records obtained in making the following studies: microphonic action of vacuum tubes; noise levels in amplifiers; investigations on rectifiers; studies on light valve flash; action of the biasing current of light valves as used in noiseless recording by the variable density method; accoustical studies showing the rise and decay of transients; loud speaker selection with regard to load carrying capacity and mechanical flutter investigations of reproducer sets. WAT (5.4)

The Cathode Ray Oscillograph. J. B. Johnson. *Bell Telephone System Technical Publications*, Monograph B-639, 1932, 27 pages.

The cathode ray oscillograph, since its invention by Braun, has developed along three lines. The major types of tubes are the high voltage tubes with a fluorescent screen, the high voltage tubes with internal photographic equipment, and the low voltage tubes. This paper follows the structural development of commercial tubes. The operation of the tubes is discussed, from the standpoint of both theory and practice, with particular reference to the low voltage type of tube. Numerous examples are given of the applications of tubes to problems in science and engineering. WAT (5.4)

The Determination of the Power Output of Amplifiers. (Ueber die Bestimmung der Ausgangsleistung von Verstärkern.) Fr. Benz. *Mitteilungen des Technischen Versuchsamtes in Wien*, Vol. 20, No. 1-4, 1931, pages 84-89.

The "capacity" of an amplifier tube is first defined, and the distinction explained as to whether the tube is a sending or receiving tube. The maximum input as a sending tube, its emitted energy as a sender, the anode loss, and its capacity as an amplifier tube are discussed and mathematically treated. Ha (5.4)

Optical Feed-Back. (Optische Rückkopplung.) Rud. Sewig. *Zeitschrift für Technische Physik*, Vol. 13, No. 4, 1932, pages 180-182.

Optical feed-back produces and modulates alternating currents of audible frequencies and produces discontinuous oscillations; the grid-circuit of a three-electrode tube contains a photocell, the anode circuit a changeable source of light. The various self-oscillating systems which can be produced with this connection are illustrated by oscillograms. Ha (5.4)

The Parallel Type Inverter. F. N. Tompkins. *Electrical Engineering*, Vol. 51, April 1932, page 263.

The inverter is a three-element hot-cathode gas-filled thyratron for the inversion or changing of d.c. into a.c.—the reverse process of the more usual rectification. The operation of the inverter differs from that of the rectifier insofar as the capacitor has to maintain the correct phase relation between input current and induced transformer primary voltage. The conditions of wave form, efficiency, power factor and regulation are analyzed, and it is shown that with proper circuit constants the voltage curve approaches a sine wave. Ha (5.4)

Methods of Counting Ions in the Free Atmosphere. (Zur Methodik der Ionenzaehlung in der freien Atmosphaere.) Yo. Itiwara. *Physikalische Zeitschrift*, Vol. 32, Jan. 15, 1931, pages 97-106.

The author states that counting tubes designed for determining the total number of small and large ions present in the atmosphere, actually do not measure the whole number of ions but only a fraction. Presumably the testing equipment is used according to the charge method, i.e., if a constant potential is observed on the outer electrode of the cylinder condenser, while the charge of the initially grounded inner electrode is measured. Some ions are deflected away from the entrance by the electric field, which is considered as the main source of trouble. Refinements in the apparatus of Gockel are pointed out. EF (5.4)

Engineering Features of Phanotron Tubes. H. C. Steiner, A. C. Gable & H. T. Maser. *Electrical Engineering*, Vol. 51, April 1932, page 263.

The phanotron is a gas or vapor filled electron tube and is a static device functioning through the movement of electrons and ions. The tube efficiency in controlling or converting power ranges from 95 to 99%. The speed as a relay is extremely fast, it works without noise or vibration, and the current capacity ranges from a few milliamperes to several hundred amperes. Phanotrons are applied as thyratrons with one or more grids for rectifiers and inverters. The performance is described in detail and oscillograms are given. Ha (5.4)

The Electronics of Transformation, Control and Regulation in High-Tension Tower Transmission Systems with Capacity, Self-induction, Inertia and Elasticity. (Die Umformungs, Steuer-und Regeltechniek in Hochspannungs-Kraftübertragungssystemen mit Kapazitat, Selbstinduktion, Massentragheit und Elastizität.) F. W. Meyer. *Elektrotechnische Zeitschrift*, Vol. 53, 1932, Feb. 11, pages 123-126; March 10, pages 242-245.

This is a theoretical investigation of the conditions which take place under the influence of electronic devices for the control and regulation of power transmissions; particular attention is paid to the operating conditions at transformation to d.c. when static high-tension charges influence the operation of the relays in such manner that oscillating phenomena of the elastically connected members of the system also begin to become noticeable. The actions in different circuits are explained in diagrams. In electronically regulated systems there exists the tendency to minimize the influence of self-induction due to the action of the relays, but on the other hand the influence of capacity is increased. The speed regulation of motor drives is improved, and where the adjustment stage passes through phases with vibrations, conditions can often be improved by rigid couplings instead of flexible couplings. Ha (5.4)

A New Apparatus for Determining the Number of Charged and Uncharged Nuclei. (Ein Apparat zur Bestimmung der Zahl der geladenen und ungeladenen Kerne.) J. Schulz. *Zeitschrift fuer Instrumentenkunde*, Vol. 51, Oct. 1931, pages 505-522.

Describes apparatus built by the G. Schulze Co. for determination of total number of condensation nuclei and of those free of charge by the application of a cylinder condenser. By the aid of a plate condenser inserted into the instrument the charge of a nucleus can be measured. The range of measurement covers 7 to 1,660,000 nuclei per ccm. Experiments were performed in the Physical Institute of the University of Gratz and in the Meteorological-magnetic Observatory at Potsdam. 5 tables of data. The new instrument was checked against the Israel condenser. EF (5.4)

The Efficiency of the Cathode-Ray-Oscillograph. (Nutzeffekt des Kathodenstrahlen-oszillographen.) M. Knoll. *Zeitschrift fuer technische Physik*, Vol. 11, Jan. 1931, pages 54-62.

Compares various methods of taking oscillograms, 38 references. EF (5.4)

A New Glass Discharge Tube for the Cathode-Ray-Oscillograph. (Ein neuartiges Entladungsrohr aus Glas fuer den Kathodenstrahloszillographen.) F. Haueff. *Zeitschrift fuer technische Physik*, Vol. 12, Nov. 1931, pages 560-562.

It is possible to select the most advantageous dimensions of the discharge tube irrespective of the exciting voltage, presumably the formation of a glow discharge is prevented by surrounding the discharge tube with a high-vacuum jacket. EF (5.4)

Sound, Vibration, Phenomena and Measurement (6.1)

Noise Measurements. (Gerausch-und Larmmessungen.) G. Bakos & S. Kagan. *Zeitschrift Verein Deutscher Ingenieure*, Vol. 77, Feb. 13, 1932, pages 145-150.

Methods and instruments are described and the results of some measurements in public places are reproduced. As a standard of loudness according to German definition a standard tone of 1000 cycles has been selected, called the phon; and the loudness is determined from the formula $S = 20 \log P/P_0$, where P is the amplitude pressure to be measured and P_0 the amplitude of the standard tone measured electrically. Ha (6.1)

Measurement of Sound Velocities of Substances in the Solid and Liquid State. (Messung der Schallgeschwindigkeit von Stoffen im festen und geschmolzenen Zustand.) M. Rinck & O. Stierstadt. *Physikalische Zeitschrift*, Vol. 32, Feb. 1, 1931, pages 124-130.

A direction finder was developed and employed for measuring sound velocities. Peculiar shape of test piece eliminates disturbances arising from the reflection of the sound waves. Thus for the first time a method was found for measuring sound speeds in melts at elevated temperatures. The changes in sound velocities at the melting point were measured for water-ice, mercury, lead, cadmium, tin and bismuth. With the exception of the last metal, the sound speeds in the solid phase proved to be twice those in the liquid state. In conclusion analogies to the thermal and electric conductivities are pointed out. EF (6.1)

Machinery Vibrations by Seismograph. *Engineering News-Record*, Vol. 108, June 23, 1932, page 886.

General Electric Co. has developed a small seismograph for the measurement, in thousandths of an inch, of vibrations in steam turbines or other machinery. Construction and operating details of the device are given. CTJ (6.1)

Some Measurements of Ship Vibration. By F. H. Todd. *North-East Coast Institution of Engineers and Shipbuilders, Advance Copy, November 1931 meeting*, 24 pages.

Vibration records were taken on 17 vessels at sea, and the amplitudes and critical frequencies recorded are given, with vibration records and details of behavior for a few of the ships. The correlation of such observations is discussed, and a simple formula proposed which will enable an approximate estimate to be made for ships, of types similar to those tested, in the very early stages of design, when only the beam, depth, length and displacement are known. (6.1)

Noise Recorder for Comparing Street-car Sounds. George Phillips. *Electronics*, March 1932, page 99.

The noise recorder consists of a three-stage audio amplifier, into which are fed electrical impulses generated in a magnetic-type of microphone, which impulses are amplified, rectified and finally recorded on an Esterline recording voltmeter. HO (6.1)

Critical Remarks on the Recording of Vibration Meters. (Kritik der Aufzeichnung von Schwingungsmessern.) W. Zeller & H. W. Koch. *Zeitschrift Verein deutscher Ingenieure*, Vol. 75, Dec. 12, 1931, pages 1509-1511.

The differential equation representing the working of a vibration meter is critically investigated and errors derived from it which must be always taken into account when evaluating the curves of such meters. Ha (6.1)

Sound and Vibration Devices or Applications (6.2)

A Voice and Ear for Telephone Measurements. A. H. Inglis, C. H. G. Gray & R. T. Jenkins. *The Bell System Technical Journal*, Vol. 11, April 1932, pages 293-317.

In order to study the physical characteristics of telephone transmitters and receivers and the physiological reactions of users of these instruments in their use, an artificial voice and ear have been developed which are sufficiently close simulations of the real voice and ear in their principal physical attributes to justify their use in both shop and laboratory tests. Their construction is described and the range in frequency and characteristics laid down in curves. The application for testing telephone apparatus is explained and results tabulated. 9 references. Ha (6.2)

The Present State of Photographic Technique Applied to the Light-sound-Registration. (Gegenwaertiger Stand der photographischen Technik bei der Licht-tonaufzeichnung.) J. Eggert, A. Kuester & R. Schmidt. *Zeitschrift fuer technische Physik*, Vol. 12, Dec. 1931, pages 639-644.

Paper at the 7. Deutscher Physiker und Mathematikertag, Bad Elster, Sept. 13-18, 1931, systematically confronts the three most important light sound methods (transversal, intensity and light sluice method) and considers (1) the properties and requirements to be met by the photographic materials, (2) the testing methods, (3) the sources and magnitudes of the distortions and disturbing noises connected with the photographic side of the sound recording. EF (6.2)

Vertical Sound Records. H. A. Frederick. *Journal Society Motion Picture Engineers*, Vol. 28, Feb. 1932, pages 141-152; *Bell Telephone System Technical Publications, Monograph* B-651, 1932, 12 pages.

Describes recent progress in laboratory studies of mechanical records of sound cut on a wax disk. Investigations indicate that a phonograph record cut with vertical undulations instead of the usual lateral undulations possesses fundamental advantages; marked increase in the volume and frequency range over which faithful reproductions may be obtained; higher volume level for same groove spacing and speed; more playing time with a given size of record and volume level. Improvements in stampers and in record material reduce surface noise and increase the volume range. Frequency range which can be reproduced satisfactorily can be extended nearly an octave to 8000 to 10,000 cycles. Other improvements: better quality of reproduction obtainable directly from a soft "wax" record and great extension in the life of the hard record. WAT (6.2)

Phonograph Pickup and Amplifier used to Test Small Bearings. *Steel*, Vol. 90, No. 13, March 28, 1932, page 39.

In conducting the test the operator slips a ball bearing assembly snugly on the rotating shaft of the motor and swings the needle arm in place with the needle in contact with the bearing. Immediately a greatly amplified and clearly audible reproduction of the scratching noise of the needle on the bearing surface issues from a loudspeaker. If this tone is a low uniform hum, the bearing surface is smooth and free from imperfections. However, if a series of disconnected, high-pitched noises is heard, the presence of irregularities on the bearing is indicated. (6.2)

Specifications of Power Noises. E. J. Abbott. *Power*, Vol. 75, Apr. 12, 1932, pages 537-540.

The application of noisemeters to power house uses are described. Total noise and frequency analyses were made. Frequency analyses were made by means of a special frequency circuit in which the response of the amplifier was confined to sound of a single frequency which could be adjusted. A large part of the noise from the gears consisted of a group of musical notes, the amplitude and frequency of each of which was measured separately. The results of 4 such analyses are presented graphically. The sound of each machine presents a distinct frequency spectrum with a different number of notes, a somewhat different frequency region, different individual frequencies and different relative importance of the various notes. AHE (6.2)

LIGHT, OPTICS, & RAYS (7)

The Wave Spectrum and Its Applications in the Different Branches of Science. (Das Frequenzband und die daran sich anschliessenden Techniken.) F. Lubbenberger. *Zeitschrift fuer die Fernmeldetechnik, Werk- und Geraetebau*, Vol. 11, Feb. 28, 1930, pages 25-32.

The significance of the wave spectrum from $\lambda = 10^{-\infty}$ (d.c.) to $\lambda = 10^{20}$ (cosmic rays) is discussed in the introduction; the physical fundamentals of the different kinds of waves are given, and the applications in the various fields of science and technology are considered. The application of waves to measuring techniques is dealt with in a special chapter. EF (7)

Light—General Measurements and Optical Applications (7.1)

Optical Refractive Power as Basis for Measuring Technique. (Optisches Brechungsvermogen als Grundlage die Messtechnik.) Bodo Voigt. *Archiv für Technisches Messen*, Vol. 1, March 30, 1932, section V44-2, page T19.

The physical phenomenon of the refraction of light and its laws are explained and the experimental basis for measurements of refraction phenomena and apparatus for it are briefly described. Ha (7.1)

The Estimation of Luster on the Basis of Luster Measurements with the Stage Photometer. (Die Beurteilung des Glanzes auf Grund der Glanzmessung mit dem Stufenphotometer.) H. Sommer. *Zellstoff & Papier*, Vol. 11, Feb. 1931, pages 77-79; *Der Papier-Fabrikant*, Vol. 29, Jan. 11, 1931, pages 20-24.

The measurement of luster by means of the stage photometer is shown which determines the increase in brightness of a surface by changing the incidence angle of the light pencil. EF (7.1)

Measurement of Fiber and Yarn Diameters by Diffraction Method. J. A. Matthew. *Journal of the Textile Institute*, Vol. 23, March 1932, pages T55-70.

The theory of this method for measuring the diameters of fine flax fibres is described which consists in viewing a light source, in this case a slit, through a bundle of fibres arranged parallel to one another and to the slit, thereby seeing a series of alternate dark and bright bands extending symmetrically on both sides of the source perpendicular to the axes of the fibres. The theory of diffraction gives a relation between the separation of the bands and the diameter of the fibres. A practical construction of the instrument, its calibration, and performance, are described in detail and a number of tests and results illustrate its use. Ha (7.1)

Operating Characteristics of the Electro-Optical Shutter. Harald W. Washburn. *Physical Review*, Vol. 39, Feb. 15, 1932, pages 688-701.

Electro-optical shutter being employed at the Univ. of Calif. in study of electrical breakdown of gases and liquids. A calculation of the time it takes the shutter to close can be made from the electrical constants of the circuit and a knowledge of the rate at which the voltage drops across the spark gap. For some experimental conditions it is sufficiently accurate to base these calculations on an electrical circuit which replaces actual distributed constants by lumped constants. In other cases error involved by this is too great. Purpose of paper to present an accurate solution of the electrical circuit taking into consideration that the constants are distributed, and thereby to bring out important facts: (1) For relatively large distributed electrical capacities of the Kerr-cell leads the rate of closing of the shutter is greater than indicated by the lumped constant solution. (2) The rate of closing is materially increased by using leads separated only by a sheet of mica instead of spacing them farther apart in air. For completeness, experimental results are given and compared with calculated results. WAT (7.1)

Automatically Constant Monochromatic Illumination from a Spark Source. George Shannon Forbes and Frank Parkhurst Brackett, Jr., *Journal American Chemical Society*, Vol. 53, Nov. 1931, pages 3973-3976.

A spark is struck between adjacent edges of two square bars moving in horizontal planes at right angles to each other. Rapid conduction and radiation of heat minimize erosion. A simplified method of following total energy at the exit slit of a monochromator is suggested and found to be accurate. The monochromatic energies obtainable, under specified conditions, from zinc, cadmium, and aluminum sparks, are listed at several wave-lengths. MEH (7.1)

Light—General Measurements and Optical Applications (7.1)

The Condition of Light- and X-Rays Through Tubes. (Die Fortleitung von Licht-und Röntgenstrahlen durch Roehren.) J. Jentzsch & E. Naehring. *Zeitschrift fuer technische Physik*, Vol. 12, March 1931, pages 185-189.

An intensification factor is defined giving the increase in radiation energy directed into an instrument if a straight tube is used. Measurement of the intensification factor in the case of X-rays. Comparison with the theory of continuous spectrum. General remarks on the intensity loss at the limit of the total reflection. EF (7.1)

Contributions to Turbidity Measurement. (Beitraege zur Truebungsmessung.) H. Sauer. *Zeitschrift fuer technische Physik*, Vol. 12, March 1931, pages 148-162.

The intensity of light dispersed by the homogeneous layers of a turbid medium is evaluated, the absorption of the primary light and the scattered light being taken into account. The dispersion formula is discussed with reference to special cases of practical importance in turbidity and fluorescence measurements. The changes in the dissipation effect of a whole turbid layer in comparison with the light scattering of an individual particle are considered and evaluated in the special case of Raleigh's Law. A rational turbidity measure is proposed for nephelometric concentration determinations and its application for measurements with the Zeiss turbidity meter is demonstrated. EF (7.1)

Stroboscopic Phenomena in Technology. (Stroboskopische Erscheinungen in der Technik.) W. Kohl. *Die Umschau*, Vol. 35, July 25, 1931, pages 591-594.

Stroboscopic phenomena and their investigation. EF (7.1)

Color Analysis, Color Matching (7.2)

Color Measurements and Color Normalization. M. J. Schoen. *Chemisch Weekblad*, Vol. 28, Feb. 7, 1931, pages 105-106.

Photo-colorimeter of Toussant which, by means of a photo-electric cell, measures the light after passing 7 different filters. The latter are now replaced by a spectroscope. The intensity curve is directly thrown upon the photographic plate. Sensitivity: 0.1%. (Human eye: 2%). EF (7.2)

The Spectral Integrator, an Auxiliary Apparatus for the Color Evaluation from Spectra. (Der Spektralintegrator, ein Hilfsapparat zur Farbenberechnung aus dem Spektrum.) S. Roesch. *Zeitschrift fuer technische Physik*, Vol. 12, Aug. 1931, pages 410-417.

An apparatus is developed for color analysis from spectra. EF (7.2)

Blancometer for Testing Whiteness. *Engineering*, Vol. 132, Oct. 23, 1931, page 540.

The instrument illustrated and described is made by Messrs. Adam Hilger, Ltd., London. The light reflected from the sample being tested is analyzed and compared with light reflected under the same conditions from a standard white surface: magnesium oxide deposited on grayed Al giving the purest white known. LFM (7.2)

An Automatic Device for Recording, Correcting and Analyzing Articulation Results. John Collard. *Electrical Communication*, Vol. 10, Jan. 1932, pages 140-146.

The quality of a telephone circuit to transmit correctly speech from one place to another is measured by the so-called articulation test which consists in taking speech sounds, vowels and consonants, and forming them at random into pronounceable syllables. These syllables are called over the circuit one by one and the listeners write down what they think each syllable is. The list of such syllables heard is then compared with the actual list of syllables spoken. This process is by nature very tedious and requires a fairly great number of men. An arrangement is described which enables caller and listener to see the results of the transmission directly on records; this is done by punched cards on the calling end which actuate a number of relays on the receiving end. The electrical details are described. Ha (6.2)

Color Matching Machine. Sheldon Electric Corporation. *Instruments*, Vol. 5, Jan. 1932, pages 22-23.

It is a photoelectric machine which measures the difference in coloring between any two samples placed in it. The difference is measured in percent variation of total intensity of reflected light, and then percent variation through standard filters. HO (7.2)

Colorimetry. (Beitrag zur Farbenmessung). A. Dresler. *Die Lichttechnik, Beiblatt zu Elektrotechnik & Maschinenbau*, Vol. 8, Aug. 30, 1931, pages 41-46.

The three-chromatic filter measurement of colors which consists in placing before the ocular lens of the photometer successively a red, green and blue filter and determining in this way the content in percent for each color in the primary color to be measured, is the most applied today. It is discussed and experimentally determined how close these measurements agree with the exact color measurement according to the theory of Young-Helmholtz. The color triangle of Maxwell developed on this theory is explained and shown how the different wave lengths can be taken from it. For practical purposes the filter method is quite sufficient as long as only qualitative measurements have to be made, that is to determine whether a source of light contains more blue or green or red than another light. Ha (7.2)

Photometry (7.3)

Measuring the Illumination from Switchboard Lamps. N. Insley. *Bell Laboratories Record*, Vol. 10, March 1932, pages 246-248.

Switchboard lamps have to give a certain luminous intensity, not an illumination of a certain area. The special photometer is described. Ha (7.3)

Direct Reading Illuminometer. Weston Electrical Instrument Corp. *Instruments*, Vol. 5, May 1932, page 136.

Brief illustrated description of new instrument consisting of an indicating instrument and a light-target assembled in a portable case. Calibrated directly in foot-candles. MFR (7.3)

A Convenient Design of Photoelectric Photometer and Its Use in Comparing X-Ray Intensities. ELMER DERSHEM. *Review of Scientific Instruments*, Vol. 3, Jan. 1932, pages 43-50.

The photometer uses the photographic effects of x-rays as measurement of their intensity; the light of a standard lamp goes through a film blackened by the X-rays and excites a photocell. The theory of photographic measurements of intensity is derived and illustrated by curves taken, the use of the instrument as spectrophotometer is explained. Ha (7.3)

A Cylindrical Rotating Sector Photometer. F. LOWELL DUNN. *Review of Scientific Instruments*, Vol. 2, Dec. 1931, pages 807-809.

A cylinder with two helically cut sectors rotates around the beam of light thrown onto a prism from which it is deflected through the sectors to the outside. The brightness of the deflected light will depend upon the portion of the sector opening to the total circumference of the rotating cylinder. Such arrangement permits a continuous variation of the light from 0 to 100%. The accuracy depends only on the exactness of the mechanical construction. Ha (7.3)

Application of the Wynn-Williams Bridge Valve Amplifier to Microphotometry and Absorption Problems. H. G. HEIL. *Philosophical Magazine and Journal of Science*, Series 7, Vol. 11, Mar. 1931, pages 736-740.

Describes the arrangements of appartus and method of measurements. Ha (7.3)

Measurement of Brightness. (Helligkeits-Messung.) RUDOLF SEWIG. *Archiv für Technisches Messen*, 1931, section V4221-1, page T68-69.

The connections and arrangements of photo-electric measuring instruments are described for the determination of the intensity of a light source; the light falls on the cell and changes its electric resistance. The function of photocells and measurements with galvanometer and electrometer are explained. Rectifier cells and resistance cells (selenium, thallium) and the amplification of the small currents are described. Ha (7.3)

Measuring Instruments for Light Distribution. (Lichtverteilungs-Messgeräte.) RUD. SEWIG. *Archiv für Technisches Messen*, Vol. 1, March 30, 1932, section J334-1, page T26.

The principles of photometry and of photometers are explained. Ha (7.3)

A New Photometer for Use in Mines. J. IVON GRAHAM. *Iron and Coal Trade Review*, Vol. 124, April 22, 1932, pages 670-671.

This instrument, developed for use in gassy mines where open flames are forbidden, is based on matching the illumination to be tested with the brightness of a series of holes situated at increasing distance from a source. The apparatus has an accuracy of ± 10%. A number of tests are described. Ha (7.3)

How Strong is the Illumination? A New Instrument for Photometric Measurements of Any Kind. (Wie stark ist die Beleuchtung? Ein neues Gerät fuer die Lichtmessung jeder Art.) O. BLOHM. *Umschau*, Vol. 35, Jan. 24, 1931, pages 76-79.

"Universal Photometer" according to Prof. Dr. Voege uses an electric bulb for comparative measurements. EF (7.3)

Polarimetry (7.4)

On the Influence of the Solvent upon the Optical Rotation. (Uber den Einfluss des Loesungsmittels auf die optische Drehung.) W. KUHN, K. FREUDENBERG & R. SEIDLER. *Zeitschrift fuer physikalische Chemie*, Section B, Vol. 13, Aug. 1931, pages 379-382.

Paper discusses the optical rotation as the sum of partly positive, partly negative directed components of the various absorption bands and correlates the resulting rotation to the influence of the solvent. EF (7.4)

A New Light Source for the Iron Spectrum. (Ueber eine neue Lichtquelle für das Eisenspektrum.) M. PIRANI & R. ROMPE. *Zeitschrift für Technische Physik*, Vol. 13, 1932, pages 134-135.

A lamp with electrodes of sintered iron powder with additions of strongly emitting substances (Barium- or Calcium-oxide) and a filling of a noble gas (neon, helium) under a pressure of a few mm. is used to produce an iron spectrum between the lines of 2000 and 5000 A units. The lamp is operated by alternating current at 220 volts and 2.5 to 5 amp. and can burn continually. Ha (7.4)

Testing of Liquids by Rotatory Polarization. (Prüfung von Flüssigkeiten durch Rotations—Polarization.) BODO VOIGHT. *Archiv für Technisches Messen*, 1931, section V932-2, page T56.

This method is used particularly for testing the purity of solutions and preparations or the composition of mixtures, as for instance in the candy industry, fermentation and celluloid industries, etc. The specific rotation power and the Biot formula is explained, the molecular rotative power defined, and methods of measuring the rotation described. A table with characteristic lines and their wave lengths are given; 12 references are cited. Ha (7.4)

Spectrometry (7.5)

Spectroscopy in the Manufacture of Glow Discharge Tubes. (Spektroskopie in der Leuchtröhren Fabrikation.) W. TELLMANN. *Glas und Apparat*, Vol. 13, Feb. 21, 1932, pages 25-27; March 6, pages 33-34; April 17, pages 57-59.

Theory of light and present ideas of structure of atom are explained by the conceptions of Sommerfeld, Bohr, Rydberg of the change of the orbit of the electrons as source of light waves in the visible spectrum. In glow tubes a neutral atom is, under the influence of an electric field, deprived of valency electrons which are carried beyond the sphere of influence of the nucleus. The latter thereby loses it's electrically neutral state and becomes a positive ion which, under the influence of the electric field, is accelerated in the direction of the latter. On its path it can again cause other electrons by its impact to change from one to another orbit. The tubes used for the production of these phenomena should contain absolutely pure noble gases; this can be ascertained by spectroscopic investigation during the manufacturing process. Several types of such tubes and the process of their manufacture are described. A table of characteristic wave-lengths of the elements is added. Ha (7.5)

A New Spectral Line Photometer for the Visible Field for the Rapid Analysis of Alloys. (Über ein neues Spektrallinienphotometer für das sichtbare Gebiet zur Schnellanalyse von Legierungen.) G. SCHEIBE and G. LIMMER. *Metallwirtschaft*, Vol. 11, Feb. 19, 1932, pages 107-110.

A new apparatus made by R. Fuess combines a spectroscope and a spectrophotometer. From an ordinary rigid spectroscope with adjustable slit diaphragm the light rays pass through a Wollaston plate, which divides them into two beams polarized perpendicularly to each other. The two spectra can be observed through a Nicol prism by turning which the intensity of the spectra can be compared. To determine alloy additions or impurities in steel the sample is used either as electrodes for sparks or as the positive electrode for an arc, carbon being used as the negative electrode. By turning the Wollaston plate, which also turns the Nicol, and by adjusting the spectroscope slit, a line corresponding to the element to be determined can be moved exactly above an iron line and their intensity compared. The instrument is calibrated by using chemically analyzed samples and choosing suitable lines for each element. The accuracy for quantitative analysis is not as great as in chemical methods, except when very small percentages are determined. The main advantage is the speed of determination, about ½ hour for a complete quantitative analysis of all elements and only a few minutes for qualitative tests. 6 references. CEM (7.5)

An X-Ray Spectrometer with Stationary Ion Chamber. RUDLOF C. HERGENROTHER. *Physics*, Vol. 2, Apr. 1932, pages 211-216.

Illustrated description of Bragg type ionization X-ray spectrometer designed for making quantitative measurements of integrated X-ray intensities reflected from crystals. Essential feature is fixed ionization chamber, allowing a short fixed connection between ion chamber and electrometer. WAT (7.5)

Workshop Spectroscope for Steel Examination. *Engineering*, Vol. 132, Dec. 11, 1932, pages 746-748.

The Spekker Steeloscope, made by Adam Hilger, Ltd., London, consists of a tripod on which is mounted a box containing the prisms. Two tubes are attached to this box, one carrying the slit and the other the eyepiece. On the eyepiece end are engraved a number of lines, each marked with the chemical symbol of one of the alloying elements. An arrow is engraved on the sliding plate carrying the eyepiece and by moving the latter so that the arrow coincides with one of the fixed marks, the part of the spectrum containing the most distinctive lines of the element to which the mark relates will be brought into the field. The elements provided for include: Cr, V, Sn, Mn, Co, Ti, Ni, Cd, Cu, W and Mo. The instrument can be secured in a modified form for examining non-ferrous metals and alloys. LFM (7.5)

The New Spectroscopy Laboratory of the Massachusetts Institute of Technology. KARL T. COMPTON. *Physics*, Vol. 2, Apr. 1932, pages 205-210.

This laboratory, built in conjunction with the erection of the new Physics-Chemistry Research Laboratories, signalizes a definite conviction that spectroscopy is destined to play a role of increasing importance in bringing about an understanding of the electrical structure of matter and of the interatomic and molecular forces which underlie the interpretation of physical and chemical phenomena. WAT (7.5)

A Periodic Radiometer for Eliminating Drifts. F. A. FIRESTONE. *The Review of Scientific Instruments*, Vol. 3, April 1932, pages 163-188.

A periodic radiometer particularly suitable for rapid recording is described, drifts being completely eliminated, while the time of response is only six seconds. Two condensers in series with the amplifying circuit effectually stop all drifts while passing the periodic deflections. By averaging visually a considerable number of deflections, the accuracy of the resonance radiometer for equal reading time can be approached so that the same instrument may serve both for rapid exploration of spectra and more careful determination of detail. (7.5)

On a New Light-Source for Absorption Measurements of Glasses in the Blue and Ultra-Violet. WILLI M. COHN. *Journal of the American Ceramic Society*, Vol. 15, Feb. 1932, pages 122-125.

On metallic thorium, when bombarded with cathode rays, a blue glow may be observed in high-vacuum as well as gas-filled tubes. The spectrum of this phenomenon is continuous, the maximum of intensity being (according to photographic determinations) at 4500° A. The spectrum has been observed from 600 to 2200° A. Lamps making use of the emission of the blue glow on thorium are described and their spectra discussed. It is shown that the new light-source has several advantages in comparison with other light-sources now in use. WAT (7.5)

Spectrogram Measuring Comparator. GAERTNER SCIENTIFIC CORP. *Instruments*, Vol. 5, Feb. 1932, page 57.

This comparator is especially designed for measuring spectrograms. The outstanding features are measuring microscope of variable power and large stage capacity. HO (7.5)

A Method of Determination of Distribution of Energy in Grating Spectra. (Ueber eine Methode zur Bestimmung der Energieverteilung in Gitterspektren.) W. DZIOBEK & U. SCHMIDTCHEK. *Zeitschrift für Technische Physik*, Vol. 13, pages 122-124.

The optical arrangement of an instrument is described which measures the energy distribution of a radiation before its impact on the grating and the spectrum of the grating. The arrangement serves also to determine the color sensibility of photographic plates. A few examples are given. Ha (7.5)

On the Technique of Spectral Intensity Measurement with Special Reference to Choice of Photographic Plate. C. W. W. READ & L. W. JOHNSON. *Philosophical Magazine and Journal of Science*, Series 7, Vol. 11, June 1931, pages 1152-1169.

The difficulties of photographic recording of a spectrum with the calibration marks are discussed and the possibilities for this method by individual calibration explained. Twenty-one references are cited. Ha (7.5)

A Method of Preserving Silver Mirrors. (Eine Methode zur Konservierung von Silberspiegeln.) H. C. BURGER & P. H. VAN CITTERT. *Zeitschrift für Physik*, Vol. 66, 1930, page 218.

Silver mirrors used in spectrographic and other work are protected with a fine deposit of quartz evaporated and deposited in a vacuum. Ha (7.5)

The "Spekker" Photometer for Ultra-Violet Spectrophotometry. F. TWYMAN. *Transactions of the Optical Society*, Vol. 33, No. 1, 1931/1932, pages 9-19.

The methods of quantitative ultra-violet spectrophotometry used so far and consisting mainly in the absorption of a substance in one beam which is compensated for by reduction either of the amount or duration of the radiation in another beam are briefly reviewed and a new instrument described which is simple enough for practical measurements. It is placed in front of a spectrograph, and the ultra-violet rays are directed to two quartz rhombs; one of the beams is then passing through an absorbing liquid, the other through the substance to be compared. A second pair of quartz rhombs combines the beams on the slit of the spectrograph; the image is then observed or measured with a photometer. The handling of the instrument, particularly the precautions to be observed, are described in detail and measurements of radiation illustrated by a photograph. 8 references. Ha (7.5)

An Infrared Spectrometer of Large Aperture. H. M. RANDALL. *Review of Scientific Instruments*, Vol. 3, April 1932, pages 196-200.

The range of this instrument which has a parabolic mirror of 24" diameter, could be extended to the region of 30 to 500 μ with a very good resolution. The prisms used with the instrument are of single crystals of KCl,KBr, and KI. An evacuated thermopile in connection with an amplifier is used for the determination of the energy of the spectral lines. Ha (7.5)

The Interpretation of Spectrograms. A. H. TAYLOR & T. KNOWLES. *Journal of the Optical Society of America*, Vol. 22, April 1932, pages 229-235.

When spectrograms are to be made to compare different light-sources or transmitting media the use of diffusing quartz over the slit of the spectrograph is recommended in order to obtain a uniformly bright source; although the required exposures are longer the results justify the greater expenditure of time. Methods of evaluating spectrograms for quantitative as well as qualitative data are described; to obtain quantitative information regarding the energy from sources in a definite spectral region a source of known similar energy distribution must be available. When making qualitative comparisons of sources having similar or dissimilar spectra, the exposures should be based on some definable condition such as illumination or total radiant energy at the position of the diffusing quartz. In the ultra-violet region, spectrograms are often misleading when used for the determination of practical wave-lengths of sources. Ha (7.5)

A Novel Apparatus for the Evaluation of Absorption Spectrograms. (Ein neuer Apparat zur Auswertung von Absorptionsspektrogrammen.) G. W. KUEHL. *Die Chemische Fabrik*, Vol. 4, Sept. 16, 1931, pages 373-374.

The conventional methods and apparatus for the evaluation of spectrograms are briefly reviewed and their drawbacks are critically discussed. A new principle was employed for the construction of a new measuring apparatus which mechanically magnifies, by lever devices, the distances measured between the different lines on the photographic plate. The great accuracy and the quick performance of the evaluation of spectrograms, particularly of absorption spectra, is emphasized. The apparatus is built by the Schmidt & Haensch Co., Berlin. EF (7.5)

A Large Grating Spectrograph. A. L. LOOMIS & G. B. KISTIAKOWSKY. *Review of Scientific Instruments*, Vol. 3, April 1932, pages 201-205.

The spectrograph consists of a plane grating with a 40 ft. focus lens; precautions are taken to keep the whole outfit at uniform temperature by a thermostat. The arrangement is described and some records are reproduced. Ha (7.5)

A New Photo-Electric Spectrophotometer. F. CAMPBELL SMITH & ENSOR R. HOLIDAY. *Transactions of the Optical Society*, Vol. 33, No. 1, 1931-1932, pages 20-25.

The photometer described is sensitive enough to be used with the hydrogen discharge tube, has no mechanical sectors or wedges, and is able to measure rapidly and accurately absorption at a given wave-length. The instrument makes use of a device by means of which absorption measurements may be made in the ultra-violet region. A photo-electric bridge is employed, one arm of which is controlled by a small fraction of the light falling on a third cell; the current from the latter can be measured galvanometrically. The two fractions are kept in constant proportion over the range of intensities used. Diagram of connections and method of handling are described fully. Ha (7.5)

A Light-Electric Spectro-Photometer. (Eine lichtelektrisches Lichtphotometer.) R. SEWIG, U. BAEHR & A. ZINKE. *Zeitschrift fuer Instrumentenkunde*, Vol. 51, Sept. 1931, pages 479-482.

Apparatus intended for determining the spectral sensitivity distribution of light-electric cells and for measuring the absorption power of filters between 4000 and 7000 A.U. EF (7.5)

The Light-Electric Spectro-Actinometer of Alt. (Das lichtelektrische Spektralaktinometer System Alt.) H. GOLDSCHMIDT & R. FLEISCHER. *Zeitschrift fuer Instrumentenkunde*, Vol. 51, Aug. 1931, pages 417-426.

Various improvements were made on the Alt spectro-actinometer which measures the intensity of the sunlight spectrometically dispersed in absolute measure over the measuring range from 300 to 720 mμ. Beside the optical parts (diffraction grating on quartz) the instrument includes a photo-cell and an electrometer which are fully described. EF (7.5)

Microscopy (7.7)

Microscope Illuminator. SUPERIOR MICROSCOPE ILLUMINATOR. *Instruments*, Vol. 5, March 1932, page 80.

Description, diagram, of device whereby a true view of the contour or the nature of surface of an object under microscope is had by light coming equally from all directions. By suitable manipulation of the light source a shadow or light or shadow can be produced at any point on the object. MPB (7.7)

A Microscopic Method. E. H. SYNGE. *Philosophical Magazine Journal of Science*, Series 7, Vol. 11, Jan. 1931, pages [illegible]

The author develops the idea of a new method of microscopic observation by which the resolution might be considerably increased; it consists essentially in investigating the opacity of a microscopic section by means of a spot of intense light whose dimensions are small in comparison with a wave-length. The spot of light is projected into the interior of the microscopic section and amplified by light-sensitive cells. The name proposed for an instrument of this kind is hyper-microscope. Ha (7.7)

Illumination of Metallurgical Specimens. CONRAD BECK. *Journal Royal Microscopical Society*, Vol. 50, 1930, pages 319-322. Roy. *Microscopical Society*, Vol. 50, 1930, pages 319-322.

For vertical illumination the prism reflector is satisfactory with low powers, but with high powers the loss of aperture and hence of resolution, is considerable. The correct use of the transparent reflector is described, the essentials being concentration of the light, complete illumination of the objective, and focussing of the light on the specimen. The question of glare is discussed and Wrighton's method for its elimination is described. It is suggested that ultra-violet illumination may not be of much value in metallurgy, as the reflective power of metals is less for ultra-violet than for visible light, and trouble due to glare is therefore accentuated. Ha (7.7)

The Theory of the Microscope. L. C. MARTIN. *Proceedings Physical Society, London*, 1931, Vol. 43, pages 186-207; discussion 207-211.

Examines the diffraction-effects produced by (a) two adjacent apertures, and (b) a series of apertures in an opaque screen situated in the focal plane of a lens system, when the illuminating system is projecting the elementary image of a point-source of light into this object plane. The diffraction-effects and geometrical resolving power of the grating are shown to be independent of the concentration of the light in the object plane; they depend rather on the number of apertures free to transmit light. The theory is then extended to the case where the illumination of the object is produced by a source of finite area. Both the equivalence and Abbe principles appear in the analysis of the mode of formation of the image in such critical illumination, but subject to the difficulties encountered in integrating for the effects of finite sources of light. Confirmatory experimental work is in hand. Ha (7.7)

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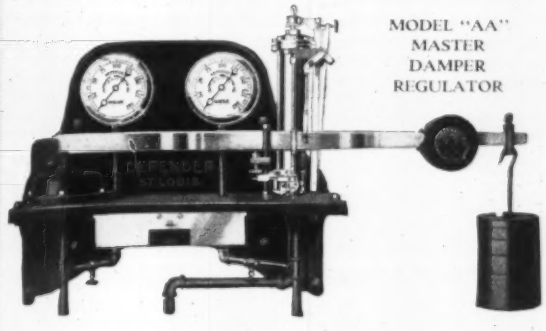

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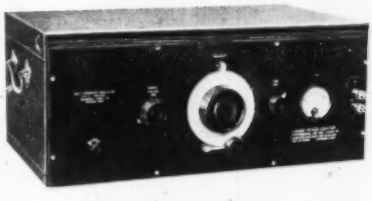

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